Journal of Chemical Education

Published by

Division of Chemical Education of The American Chemical Society

Easton, Pa.

Entered as Second-class Matter, January 31, 1924, at the Post Office at Easton, Pa., under the Act of March 3, 1879. Acceptance for mailing, at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized January 31, 1924

Vol. III **August, 1926** **No. 8**

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DER ALCHYMIST
BY EDM. HEILMER

EDITOR'S OUTLOOK

The Extension of Education

THE American Library Association, in a recent report, points out that although the American system of formal education offers an opportunity to all, it actually reaches but sixty-four per cent of the youth of the country. Of the average group of one hundred children of school age, *thirty-six are not attending school at all*, fifty-four are attending public elementary school, seven are attending public high school and three are in public night school or vocational school. Only two enter a college or university.

An effective answer, surely, to the occasional intellectual snob who bemoans the waste of money and effort involved in our attempts at universal education and deplores the fact that the college degree is now so prevalent as to carry with it no special mark of distinction.

What other means, then, are available for extending to the general public the benefits which it in large proportion fails to derive from our formal educational system? We agree with the American Library Association that the radio and the moving picture, while possessed of great potentialties, are, as at present constituted, almost wholly recreational rather than educational. Magazines and newspapers are of value chiefly to those who, by reason of previous education, are able to turn them to account.

The Association believes that books made freely and easily available offer the greatest possibilities of usefulness, for they alone, of all the agencies at hand, afford the materials for beginning an education or continuing its progress at any point. The American library can, by furnishing books and, what is more important still, encouragement and guidance in their selection and use, make an effective contribution to the present problem of national education. This, too, without conflicting with any other movement directed toward a like end, but rather in coöperation with all existing agencies.

The American Library Association* is a national advisory body of 6800 libraries throughout the country, engaged in a program to create library facilities for the fifty million or more people throughout the United States and Canada to whom they are not now available and to make the public library a means of education to the American youth who do not or cannot attend public school. To achieve this end a program of coöperation with every willing public and private agency has been begun. The Association has placed the resources of its members at the disposal of State Library Boards, of Town, Village, County, and City Committees on Education and of all other bodies engaged in furthering education.

* 86 East Randolph Street, Chicago, Illinois.

Yet the magnitude and far-reaching importance of this work require the aid of all for its achievement. The Association asks the coöperation of business organizations, of churches, of School Boards, of institutions and clubs, indeed of all organizations and individuals interested in the spread of education in America.

While we have spoken with particular reference to those deprived of the advantages of public school education, we feel that there is as great a need for the extension of the period of education beyond the school age. The teacher who succeeds in implanting in his pupils the reading habit will have given them as much of permanent value as they will ever derive from his more formal instruction.

The Philadelphia Meeting

THE American Chemical Society celebrates its semi-centennial anniversary coincidentally with the more widely heralded sesquicentennial of the nation. Happily, those in charge of arrangements chose the exposition city for the meeting-place of the Society. The opportunity to visit the exhibits on display there, the numerous chemical plants which may be inspected, and the special efforts that are being put forth to prepare a program of unique merit should combine to produce one of the most memorable occasions in the history of the organization.

For the Division of Chemical Education five half-day sessions (Sept. 6th–11th) have been planned. These will include: (1) A symposium on "International Chemical Education" in which prominent speakers from England, France, Holland, and other countries will participate. (2) A round-table discussion on the topic, "What Is Chemical Engineering?" including various views as to what a course in chemical engineering should include. (3) A joint session with the Section of History of Chemistry. Dr. Newell has a particularly interesting and profitable program in preparation for this meeting. (4) A session devoted to miscellaneous papers on various phases of chemical education. (5) A session devoted to papers of particular interest to teachers of chemistry in secondary schools.

Abstracts of a number of the papers to be presented are available as we go to press. They appear on pages 953–7 of this number.

The Division will, of course, contrive to include its usual business session. A number of important matters await decision.

Other features of the educational program will be the meeting of the Senate of Chemical Education on Thursday afternoon, September 9th, and a dinner for the editors of the JOURNAL at the Bellevue Stratford at six-thirty of the same evening.

THE CHEMISTRY OF LEATHER MANUFACTURE*

Applying Modern Science to an Ancient Art

HENRY B. MERRILL, A. F. GALLUN & SONS CO., MILWAUKEE, WIS.

Tanning, or leather manufacture, is a very ancient art. It is an art that is known and practised by even the most primitive races; it is an art that was practised with very considerable skill by the earliest of civilized peoples. The Babylonians and Egyptians made leather very much as it is made today, and if one may judge from certain Babylonian laws that have survived, tanning has remained essentially the same for five thousand years. The Babylonian code provided that prayers, to be acceptable to God, must not be offered up within a prescribed distance from a tannery; another humane provision decreed that a tanner's wife might divorce him at any time without ceremony.

The use of skins for clothing must have begun very early in human development. Raw skin, however, is not at all desirable as a garment, as it is highly putrescible. It can be kept from rotting, among other ways, by being dried, and no doubt this was the treatment first employed by primitive men. But a dried skin is so hard and stiff as to be almost unusable. With the idea, we may suppose, of rendering the skin more pliable, men began to rub animal fats into the dried hide. The animal fat did more than lubricate the skin; oxidizable oils have a real *tanning* action—that is, they combine with the skin substance to form a stable substance that will not rot—a *leather*. Oil tannage is used today for such leathers as chamois and so-called raw-hide.

Later on, probably, leather workers discovered that a skin could also be made into leather by being soaked in a decoction of bark or wood from any one of a large number of trees. Very much more recently, it has been discovered that solutions of chromium salts accomplish the same result. Meanwhile, tanners had learned how to take off the hair without injuring the skin, how to lubricate, how to color, and how to apply lacquers to the finished product. In short, the art of making leather became highly developed, and all with little or no aid from science.

The application of science to the leather industry is a development, mostly, of the twentieth century. We still have an immense way to go before we can express every part of the process in terms of physics and chemistry, but at least we have made progress and are in possession of fairly adequate working theories as to what goes on when a skin is transformed to leather. This progress has been made by following up two lines of study: (1) the micro-structure of the skin, and (2) the physical chemistry of the proteins.

* Presented before the Second Annual Meeting of the Section of Teachers of Chemistry of the Wisconsin State Educational Association, Milwaukee, Wis., November 6, 1925.

In Figure 1 we have a highly magnified vertical section through a fresh calf skin. The main body of the skin is made up of interlacing fibers composed of the protein collagen. On the side of the skin next the body (the flesh side) is a layer of adhering fat and other tissue. Above the fibrous "true" skin, or "derma" lies a very different structure—the epidermis. The epidermis is composed of several layers of living and dead cells. The lowest tier of cells absorbs nourishment from the solutions impregnating the derma, and lives on the surface of the body almost like a parasite. These cells reproduce by division vertically. As new cells are formed, the old ones are pushed nearer the surface, are deprived of nourishment, die, dry up, and at length are rubbed off. Dandruff is nothing but these dead, dried up cells of the epidermis.

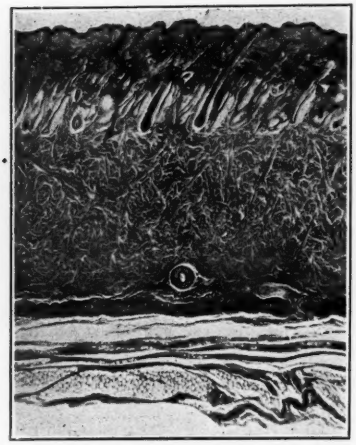


FIG. 1.—Cross section of fresh calf skin. Magnified 30 diameters.

The hairs grow in pockets in the epidermis, where the latter dips down into the true skin. Each hair is accompanied by a fat gland, a sweat gland, and a little muscle. This system helps maintain the body at a constant temperature. When the body is warm, the erector muscles are relaxed, allowing the sweat glands to pour forth their secretion onto the surface of the skin, cooling the body by evaporation. But when the skin is chilled, the tiny muscles contract, cutting off the sweat flow, erecting the hair to form a bushy covering, and squeezing out the contents of the fat glands, thus cutting off evaporation. In the human subject, this produces goose-flesh.

The skins of different animals differ considerably in details, especially in the texture of the fibrous true skin. In the calf or cow, the fibers are very numerous in a given volume, and are tightly interlaced, producing a very firm, tough, durable leather. In other species, for instance the goat, and still more so in the case of the sheep, the fibers occupy a much smaller proportion of the total volume of the skin, and this causes kid or sheep leather to be soft, spongy, and limp.

The fibrous true skin is the only portion of the hide that is suitable for leather. It is the tanner's first task to remove both the flesh layer and the entire epidermal system, including the hair.

Skins as received in the tannery are usually dried or salted. It is neces-

sary first of all to restore the skin as nearly as possible to the condition in which it existed on the animal's back. This is accomplished by soaking the skin in water for several days. It is highly important, during this stage, to retard bacterial growth as much as possible, which end is accomplished by keeping down the temperature and changing the water frequently. After the soaking operation is complete, the skin is in the condition of a jelly, containing about eighty per cent of water, and easily penetrable by the various solutions to whose action it is to be subjected.

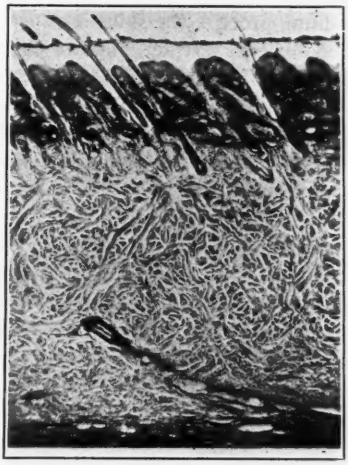


FIG. 2.—Cross section of calf skin after liming, before unhairing. Magnified 35 diameters.

Next comes the removal of the hair. The skin is treated with a saturated solution of lime, to which is often added a little sodium sulfide. An excess of lime is used to maintain a constant hydroxyl-ion concentration. At the alkalinity of saturated lime water, $p_H = 12.5$, the cells of the lower layer of the epidermis are attacked before any appreciable hydrolysis of the true skin occurs. During liming the lower layers of the epidermis are dissolved away (Figure 2), leaving the hairs loose in their follicles, and by means of a blunt knife or a suitable machine the hair and other remnants of the epidermis are easily scraped away.

Either before or after liming, the flesh layer is cut away by another machine.

The skin as it comes out of the lime liquor is swollen and rubbery. Before being tanned, it must be reduced to a soft and flaccid state, and delimed, since tanning can occur only in slightly acid solution. This is brought about by a very curious process known as "bating." Originally this process consisted in digesting the skins in an infusion of dog dung or pigeon manure. This repulsive material has now given place to artificial bates. The old dung bates owed their efficacy to two constituents—ammonium salts, which remove lime and bring the skin to a p_H value of about 8, and digestive enzymes, which remove certain minor constituents of the skin whose presence in the finished leather is objectionable. Artificial bates consist essentially of ammonium salts and pancreatic enzymes from the packing houses.

Two distinct methods of tanning are in general use for all kinds of leather.

These employ, respectively, natural tanning materials—oak, chestnut, hemlock, and many other barks, quebracho wood from South America, and other exotic plant materials, and chromium salts. In the natural tanning process, the skins are suspended, first, in a very weak solution of wood or bark extract, and are shifted daily into successively stronger liquors, until the tannin has "struck through." The hydrogen-ion concentration of the liquors must be carefully regulated, since if the liquor gets too acid the skins become swollen and distorted,[1] while if the liquor is not acid enough the fixation of tannin is reduced, and the resulting leather will be flat and "empty." This natural tanning process requires from a week up to several months, depending on the thickness of the skins. In mineral tanning, the skins are treated with a slightly acid solution of chromium sulfate. After the liquor has penetrated the skins, bicarbonate of soda is added to bring the acidity down to the point just above that at which precipitation of chromium hydroxide would take place. The chromium then combines with the fibers, as does also considerable sulfuric acid.

The theory of vegetable tannage is in a fairly satisfactory state. We know that collagen, like other proteins, is built up of amino acids. These amino acids are amphoteric, and the property of combining with either acid or base is also possessed by the protein. On the acid side of its isoelectric point, collagen behaves like a weak base. The tannins, on the other hand, are weak acids. Thus, when a skin is placed in a weakly acid solution of a tannin, the basic protein and the acid tannin combine chemically to form a new compound—collagen tannate. The mechanism of chrome tanning is not quite so clear. We believe that the final product is chromium collagenate, in which the chromium acts as the base and the collagen as the acid, but there is some reason to think that at first the combination is between collagen and some of the complex ions that chromium forms so very readily.

Chrome tannage has largely displaced natural tannage for light leathers, such as are used for the uppers of shoes. This has come about because chrome tannage is much quicker, cheaper, and less difficult to regulate properly than the older method. This change has not been altogether a blessing to the consumer. Chrome leather (Figure 4) has a much looser texture than natural-tanned leather (Figure 3), because chromium has a much lower combining weight than the complex tannin molecule, and consequently a given weight of skin substance combines with very much less chrome than tannin. Chrome leather is, therefore, spongier and stretches

[1] The effect of acids, bases, and salts upon the swelling of skin—a problem which occurs in the leather manufacturing process at almost every stage—is a beautiful example of the application of pure scientific research to an industrial problem. See "The Chemistry of Leather Manufacture" (A. C. S. Monograph) by John Arthur Wilson; and Jacques Loeb, "Proteins and the Theory of Colloidal Behavior," 2nd edition, New York, 1924.

more easily than natural leather. Chrome leather also contains several per cent of sulfuric acid in combination with the collagen, it is true; still, a portion of this acid may at times be liberated by hydrolysis and cause chrome leather shoes to impart a slight burning sensation to the feet after a long walk. Perhaps due to its acid content, chrome leather takes on and gives up moisture to a much greater extent than does natural-tanned leather with changes in atmospheric humidity. With the change in water content goes a great change in area, and consequently a considerable change in the size of chrome leather shoes every time the weather changes. This may be

FIG. 3.—Natural tanned calf skin. Magnified 75 diameters.

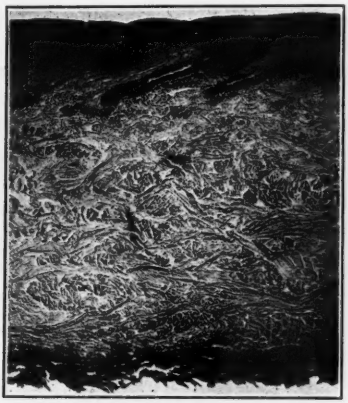


FIG. 4.—Chrome tanned calf skin. Magnified 75 diameters.

an advantage to amateur weather prophets, who are wont to foretell changes by the deportment of their corns, but scarcely to the general run of shoe wearers.

When the skin comes out of the last tan vat, or the chrome tanning drum, its conversion into leather is complete. Leather at this stage, however, is far from being a merchantable product. The operations performed on the skin subsequent to tanning include: (1) *fat-liquoring*, whereby oil (in some cases as much as 15–20% of the weight of the skin) is incorporated by drumming the skin in an emulsion; (2) *coloring*, now done chiefly with coal-tar dyes; and (3) *finishing*, which consists in the application of a thin, lustrous coating to the grain surface. Besides these main operations, each skin is subjected to a great variety of purely mechanical treatments, too numerous to enumerate.

The application of this brief survey of the chemistry of leather manufac-

ture to chemical education is to be found, probably, in the instruction of those students who pursue chemistry as a cultural rather than as a professional subject. It is of little use to try to instruct a prospective chemist in the practical details of making leather. If he is to be of use, as a chemist, in the tannery, it can only be through his ability to apply the fundamental principles of science to the problems that he will be called upon to solve. The best service that educational institutions can give to future industrial chemists is to give them all the pure chemistry they can absorb—the more the better.

It is, however, very regrettable that the public in general knows so little about the chemistry of so universally used a product as leather, and especially about the differences in skins and methods of tanning that produce such marked differences in the shoes we wear. It is not too much to say that most shoes are purchased because of fine points of superficial appearance that cease to exist before the shoes have been worn a week. This ignorance it may be the function of the chemistry teacher to dispel.

And, finally, it may be that the beginning student will be interested to learn that

$$\text{Skin substance} + \text{tannin} = \text{leather}$$

is just as good an example of a chemical equation as

$$2H_2 + O_2 = 2H_2O.$$

The former equation has the additional merit of being easy to balance.

Fish Valuable Food Says Scientist. Mineral elements necessary for human nutrition lacking in most foods are supplied by fish. According to Dr. Donald K. Tressler, of the Mellon Institute of Industrial Research, we should all eat more sea food to supply the calcium, phosphorus, and iodine constituents lacking in most ordinary diets.

Canned fish, he said, is particularly desirable because the bones as well as the flesh are eaten. The value of fish bones lies in the fact that they consist almost entirely of calcium phosphate, necessary for growth and repair of human bones and teeth.

The generally recognized fact that small quantities of iodine in the diet will prevent or help goiter and other disturbances of the thyroid gland is a strong argument, declared Dr. Tressler, for an increased consumption of fish and the edible seaweeds. Both sea foods and plants are known to contain more of this necessary element than anything that grows on land.

Scientists have found that the fats and proteins of fish are as easily digested as those of meat. By careful analysis it has been found, according to Dr. Tressler, that "upon digestion fish proteins furnish all of the amino acids needed for the building up of the complex protoplasmic structure we call our body. All of the amino acids needed for the construction and repair of our bodies occur in ample proportions. Curiously, the composition of fish proteins resembles that of the proteins of chicken muscles. This fact is especially important when we consider the high nutritive value ordinarily assigned to chicken meat."—*Science Service*

THE EMERALD TABLE OF HERMES TRISMEGISTUS

Three Latin Versions Which Were Current among Later Alchemists

TENNEY L. DAVIS, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS.

Whenever a chemist speaks of a vessel which is hermetically sealed, he pays homage to the legendary founder of his science, to Hermes Trismegistus, the Three Times Great, prince, poet, and philosopher. "And this is that Hermes which after the flood was the first finder-out and setter-forth of all arts and disciplines both liberal and mechanical." He is supposed to have summarized the essential secrets of alchemy in succinct sentences inscribed on a tablet of emerald, which tablet he caused to be buried with his own body, content in the belief that in due time the proper person would find it. One legend tells that the table was found by a woman named Sara in a pit near Hebron, another that it was discovered by Alexander the Great and brought back by him from his travels. There are also other legends—and the origin of the table is covered with obscurity. The word, *telesmus* (τελεσμος, completion, finishing), in the Latin version suggests that that version was derived from a Greek original. Holmyard[1] has recently found evidence which indicates that it was known to Apollonius of Tyana. The Emerald Table, therefore, is about as old as the Christian era.

Jābir ibn Ḥayyān, who lived in the eighth century and is probably the true Arabic author of the Latin treatises ascribed to Geber, in his Kitāb Ustuqus al-Uss or Book of the Firm Foundation, quotes from the table on the authority of Balīnās, that is, on the authority of Apollonius of Tyana, as follows—"Balīnās mentions the engraving on the table in the hand of Hermes, which says: 'Truth! Certainly! That in which there is no doubt! That which is above is from that which is below, and that which is below is from that which is above, working the miracles of one thing. As all things were from One. Its father is the Sun and its mother the Moon. The Earth carried it in her belly, and the Wind nourished it in her belly, as Earth which shall become Fire. Feed the Earth with that which is subtle, with the greatest power. It ascends from the earth to the heaven and becomes ruler over that which is above and that which is below. And I have already explained the meaning of the whole of this in two of these books of mine.' "

In the *Liber de Compositione Alchemiae* of Morienus,[2] which Robert

[1] E. J. Holmyard, *Nature*, **112**, 523 (October, 1923).

[2] In the collection of alchemical tracts entitled "Artis Auriferae, quam Chemiam vocant," 2nd ed., Basileæ, **1593**, vol. 2, p. 26. *Hermes quoque ait: Terra est mater elementorum: de terra procedunt, & ad terram revertuntur. Hermes iterum ait: Quomodo omnia ex uno procedunt, sic meum magisterium ex una fit substantia, & materia.* The entire treatise, with notes by Holmyard, has recently been published in the quaint language of a seventeenth century English translation preserved in the British Museum (Sloane MS. 3697) in *Chemistry and Industry*, **44**, 75, 105, 136, 272, 300, 327 (1925).

Castrensis (Robert of Chester?) translated out of Arabic into Latin on the eleventh day of February in the year 1182,[3] sentences occur which suggest that the author of the work was perhaps acquainted with the Emerald Table. "Hermes also says, 'The earth is the mother of the elements; they proceed from the earth, and they return again to the earth.' Hermes says again, 'As all things proceed from one, so my magistery is made from one substance and one material.' "

The Emerald Table appears to have been first printed at Nuremberg in 1541 in a Latin version by an unknown translator, and was accompanied by the commentary (Appendix 1) of a certain Hortulanus who offered no suggestion as to the source of the original and none as to the language from which the translation was made.[4] Nothing is known concerning Hortulanus, for his suggested identity with John Garland (1202–1253) has not been established. Yet it seems certain that the alchemists of the thirteenth century were acquainted with the Latin version upon which Hortulanus wrote his commentary, for Albertus Magnus (1193–1280) quotes from Hermes in language which forms a portion of it.

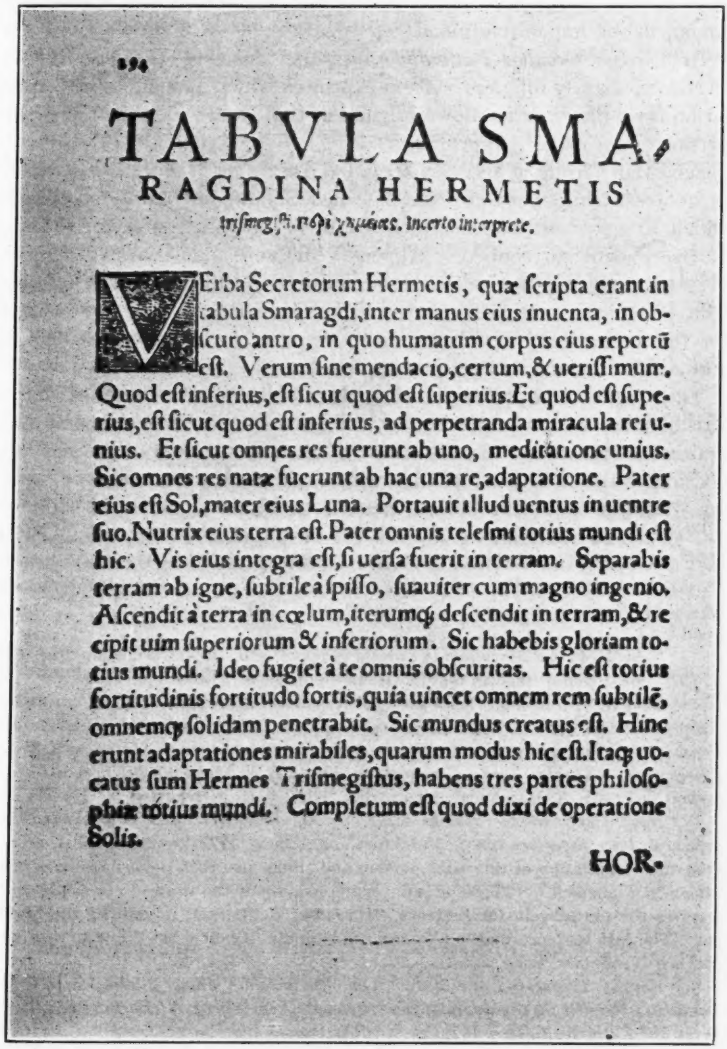
In his treatise, *De mineralibus et rebus metallicis*,[5] Albert says, *lib. 1, tract. 1, cap. 2*, "and Hermes teaches this highest achievement of the alchemists in the secret of his most secret things, saying, in metaphorical language, that the stone ascends gently with great ingenuity from the earth to the sky and again descends from the sky to the earth, its nurse is the earth, and the wind bore it in its belly," and *lib. 3, tract. 1, cap. 6*, "Father Hermes Trismegistus is seen to approve this opinion who says that the earth is the mother of the metals and the sky the father, and that the earth is impregnated by him in the mountains, in the open fields, in the waters, and in all other places," and *lib. 3, tract. 2, cap. 1*, "Hermes says that the producer of metal is the earth and that it bears it in its belly."

[3] Dated for the Spanish era, actually 1144.

[4] The page reproduced with the present article and the translation of Appendix 1 are from the Nuremberg edition of 1545, *Alchemiae Gebri Arabis philosophi solertissimi, Libri, cum Reliquis*, the Table, p. 294, and the Commentary of Hortulanus, p. 295. The same is also printed in French translation in *Le Miroir d'Alquimie* of Jean de Mehun, Paris, **1613**, the Table, p. 35, and the Commentary, p. 38: also Dr. Allendy, *La Table D'Emeraude D'Hermes Trismegiste avec les commentaires d'Hortulain*, Paris, **1921**.

[5] *Raimundi Lullii Maiorici Philosophi acutissimi, medicique celeberimi, De secretis naturae sive Quinta essentia libri duo. His accesserunt Alberti Magni Summi philosophi, De mineralibus et rebus metallicis Libri quinque*, bound up in one volume with continuous pagination, Argentorati, **1541**, p. 62, *et hoc summum ingenium alchimicorum docet Hermes in secreto secretissimorum suorum per verba metaphorica dicens lapis suaviter cum magno ingenio ascendit a terra in coelum, iterumque descendit a coelo in terram, nutrix eius terra est, et portavit eum in ventre ventus suo.;* facing p. 140, *Hanc opinionem pater Hermes trismegistus approbare videtur, qui dicit terram esse matrem metallorum et coelum patrem et impregnari terram ab hoc in montibus campestris et planis et in aquis et ceteris omnibus locis*, and p. 150, *dicit Hermes quod genitrix metalli est terra quae portat ipsum in ventre suo.*

The expression, "its nurse is the earth" (*nutrix eius terra est*), is identical with that of the version which Hortulanus used, but differs from the expression, "it is nursed by the earth" (*nutitur à terra*), in the version which was later published by Kriegsmann. The words of Albert, *suaviter cum*



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TABVLA SMA-
RAGDINA HERMETIS

trismegisti. περὶ χημείας. Incerto interprete.

VErba Secretorum Hermetis, quæ ſcripta erant in tabula Smaragdi, inter manus eius inuenta, in obſcuro antro, in quo humatum corpus eius repertũ eſt. Verum ſine mendacio, certum, & uerißimum. Quod eſt inferius, eſt ſicut quod eſt ſuperius. Et quod eſt ſuperius, eſt ſicut quod eſt inferius, ad perpetranda miracula rei unius. Et ſicut omnes res fuerunt ab uno, meditatione unius. Sic omnes res natæ fuerunt ab hac una re, adaptatione. Pater eius eſt Sol, mater eius Luna. Portauit illud uentus in uentre ſuo. Nutrix eius terra eſt. Pater omnis teleſmi totius mundi eſt hic. Vis eius integra eſt, ſi uerſa fuerit in terram. Separabis terram ab igne, ſubtile à ſpiſſo, ſuauiter cum magno ingenio. Aſcendit à terra in cœlum, iterumq; deſcendit in terram, & recipit uim ſuperiorum & inferiorum. Sic habebis gloriam totius mundi. Ideo fugiet à te omnis obſcuritas. Hic eſt totius fortitudinis fortitudo fortis, quia uincet omnem rem ſubtilẽ, omnemq; ſolidam penetrabit. Sic mundus creatus eſt. Hinc erunt adaptationes mirabiles, quarum modus hic eſt. Itaq; uocatus ſum Hermes Triſmegiſtus, habens tres partes philoſophiæ totius mundi. Completum eſt quod dixi de operatione Solis.

HOR.

The Emerald Table of Hermes Trismegistus

magno ingenio ascendit a terra in coelum, iterumque descendit in terram, occur likewise in the version which Hortulanus used, except that there is a period after *ingenio* which considerably alters the sense. Kriegsmann has the corresponding portion of the Table in quite different language, "ascend with the greatest sagacity of genius" (*summa ascende ingenii sagacitate*), in the imperative mood.

In *Aureliae Occultae Philosophorum partes duae, M. Georgio Beato Interprete*[6] a slightly different version is printed which appears to be a translation from the same unknown original as that from which the more usual version was made (Appendix 2).

Sebastian Wirdig in his *Nova Medicina Spirituum*,[7] *lib. ii., cap. xxii, sect. 4*, quotes a third version, "the so-called Smaragdine Table of Hermes, which Kriegsmann[8] (*sic*) has turned into Latin while conserving the sense of the Phoenician context" (Appendix 3), and adds that it "describes very perfectly the fabrication of the universal medicine." The reference to a Phoenician original conforms to old tradition and may be evidence for the authenticity of Kriegsmann's version,[9] but it may also be only a device for making a forgery more plausible.

The religious and philosophical writings which bear the name of Hermes Trismegistus are probably the work of a school which flourished at Alexandria in the third century of our era.[10] Those who have studied them have considered the alchemical writings which bear the same name to be "spurious," that is, they have judged them not to be the work of this Hermetic

[6] *Theatrum Chemicum*, vol. 4, p. 564, Argentorati, 1613, evidently the same as the work reported by Du Fresnoy, *Azoth, seu Aureliae occultae Philosophorum, materiam primam & decantatum illum Lapidem Philosophorum, filiis Hermetis solide explicantes, M. Georgio Beato Fr. Interprete.* Francofurti, 1613. The work contains many symbolic wood-cuts.

[7] *Nova Medicina Spirituum: Curiosa Scientia*, etc. (in Latin), Hamburg, **1688**, p. 157. Du Fresnoy reports only a German edition of Franckfort, **1706.**

[8] Evidently, *Guillelm. Christophor. Kriegsmanni Commentariolus interpres Tabulae Hermetis Smaragdinae.* "Sine loco et anno Impressionis" (probably 1657), also *Hermetis Trismegisti Tabula Smaragdina, cui Titulus Verba Secretorum Hermetis Trismegisti, W. Chr. Kriegsmanni et Gerardi Dornei Commentariis illustrata*, in Manget's *Bibliotheca Chemica curiosa*, vol. 1, p. 380, Coloniae Allobrogum, 1702: both as reported by Du Fresnoy.

[9] *Neue Alchymistische Bibliothek für den Naturkundiger unsers Jahrhunderts ausgesucht und herausgegeben von S.*, Frankfurt und Leipzig, **1772**, contains, vol. 1, preface, a German translation of this same version and states also that the original was in the Phoenician language. It has the same expression about the word of one GOD, but it reverses the phrasing in the sentence, "Its father is the Sun, its mother the Moon," etc. The last sentence makes reference, not to the "Chemic art," but to *dem allerhöchsten Werke* (*der Scheidekunst*).

[10] *Hermès Trismégiste, Traduction Complète précédée d'une Étude Sur L'Origine Des Livres Hermétique par Louis Ménard*, 3rd. ed., Paris, **1910:** *Hermetica, The Ancient Greek and Latin Writings Which Contain Religious or Philosophic Teachings Ascribed to Hermes Trismegistus, edited with English translation and notes by Walter Scott*, 4 vols., Oxford Univ. Press, vol. **1,** 1924.

School—and it has been assumed in consequence that they belong to a later date. If the Emerald Table was known to Apollonius of Tyana, then it was known three centuries before the Alexandrian school, and may perhaps have pertained to the earlier Hermetic tradition from which the later cult acquired its name and perhaps, its leading ideas. It may even be that the Emerald Table has something of the great antiquity which legend ascribes to it.

Since the most usual Latin version contains a Greek word, it seems likely that it was derived from a Greek original. The lack of the same word in another Latin version, which nevertheless appears to be derived from the same original, gives no cause for particular question. The third version, which appears to be derived from a different original, raises the interesting question whether two versions existed in the Greek. If so, from what original were they derived? If not, in what other language then was this other version?—and was it earlier or later than the Greek? The proof that Kriegsmann's version is a fabrication involves all the difficulty of proving a negative, and is not to be hoped for. Probable proof that it is genuine would be supplied by the discovery of an early manuscript of the same version, in which case, of course, the credit might not be to Kriegsmann for translating the Table out of the Phoenician into the Latin. And the positive proof which the original of his translation would supply would throw much light upon the antiquity of the Table.

At first glance the Table appears to contain no chemistry. It asserts the essential unity of the world, and perhaps refers to spiritual things, intending a monistic metaphysics. Perhaps on the other hand it asserts the fundamental unity of matter, as Hortulanus understood it and as modern physics is coming to believe. It also describes a process of purification or strengthening, perhaps the mystical process by which Heaven and Earth are one without distinction, perhaps the preparation of the Medicine by sublimation and distillation. Hortulanus found alchemical doctrine in it, and later commentators found even more than he. The many discussions which have been written upon it, the alchemy which has been elicited from it—perhaps indeed the alchemy which has been read into it—have made it one of the most important documents in the history of primitive chemistry.

APPENDIX 1. *The Emerald Table and the Commentary of Hortulanus.*
TRANSLATION.

The Smaragdine Table of Hermes Trismegistus, *περὶ χημείας.*

By an Unknown Translator

The words of the Secrets of Hermes which were written on the table of Smaragd which was found between his hands in an obscure cave in which his buried body was discovered.

True without lie, certain, and most true. That which is below is as that which is above, and that which is above is as that which is below, for accomplishing the miracles of a single thing. And as all things were from one, by the meditation of one, so all things were born from this one thing, by adaptation. The father of it is the Sun, the mother of it the Moon. The wind bore it in its belly. Its nurse is the earth. The father of all the telesmus of the whole world is here. Its force is unimpaired if it is turned into earth. You will separate the earth from the fire, the subtle from the dense, carefully and with great ingenuity. It ascends from the earth into the sky and again descends to the earth, and it receives the force of things above and of things below. So you will have the glory of the whole world, and so all obscurity will fly from you. Here is the strong fortitude of all fortitude, for it will conquer everything subtle and will penetrate everything solid. So the world was created. Hence there will be marvelous adaptations of which this is the mode. And so I am called Hermes Trismegistus, having three parts of the philosophy of the whole world. It is complete what I have said concerning the operation of the Sun.

The Little Commentary of Hortulanus, the Philosopher of the Maritime Gardens, on the Smaragdine Table of Hermes Trismegistus, περὶ χημείας.

Prayer of Hortulanus.

Praise, honor, strength, and glory be to thee, Lord God omnipotent, and to thy beloved son, our Lord Jesus Christ, and to the holy Spirit comforter. Holy Trinity which alone is God, and one and perfect man, I give thanks to thee, for, when I had become thoroughly acquainted with the transitory things of this daily world, in order that I might not be provoked by its delights, in thy very great mercy thou hast drawn me away from it. But, since I see infinite many working in this art who are deceived and who do not enter upon the right route, may it please thee, my God and Master, that, out of the science which thou hast entrusted to me, I may lead my dear ones away from this error, so that when they shall have perceived the truth, they may praise thy holy and glorious name which is blessed for ever. Amen.

Preface.

I, Hortulanus (or Gardener), so called from the maritime gardens, wrapped in the garment of Jacob, unworthy to be called a disciple of philosophy, moved by the love of those who are dear to me, now intend to set forth a most certain Declaration of the Sermon of Hermes, the father of philosophers, which sermon, although it may be occult, nevertheless has

declared the exercise of the true work, the whole exposition truly in the weariness of my fingers. Surely the obscurity of the philosophers appears as nothing in discourses where the doctrine of the holy spirit operates.

Chapter I. That the Art of Alchemy is true and certain.

The philosopher says: TRUE, namely, that the art of alchemy is given to us. WITHOUT LIE, he says this to the detestation of those who say that the art is mendacious or false. CERTAIN, it has been proved by experience. For whatever has been proved by experience is most certain, AND MOST TRUE, for the most true Sun is procreated by art. And he says most true in the superlative degree because the Sun generated by this art exceeds all natural Sun in all of its properties, medicinal and otherwise.

Chapter II. That the stone ought to be divided into two parts.

In the following he touches upon the operation of the stone saying, THAT WHICH IS BELOW IS AS THAT WHICH IS ABOVE. And this is the same as saying that the stone is divided into two principal parts by the magistery, into a superior part which ascends above and into an inferior part which remains below fixed and clear. And these two parts moreover are concordant in their virtue. And it is for this reason that he says: THAT WHICH IS ABOVE IS AS THAT WHICH IS BELOW. Surely this division is necessary, FOR ACCOMPLISHING THE MIRACLES OF A SINGLE THING, that is to say, of the stone. Since the inferior part is earth which is called Nurse and ferment, and the superior part is the spirit which vivifies and resuscitates the whole stone and likewise is made by separation and celebrated conjunction, then many miracles are accomplished in the secret work of nature.

Chapter III. That the stone has in itself the four elements.

AND AS ALL THINGS WERE FROM ONE BY THE MEDITATION OF ONE. He gives an example here, saying: As all things were from one, namely, from a confused globe, or a confused mass, by the meditation, that is, by the cogitation and creation, of One, that is, of omnipotent God, SO ALL THINGS WERE BORN, that is, they came forth, FROM THIS ONE THING, that is, from one confused mass, BY ADAPTATION, that is, by the single command and miracle of God. So our stone, which was created by God, was born and came forth from a confused mass, containing in itself all the elements—and hence our stone was born by his single miracle.

Chapter IV. That the stone has a father and a mother, namely, the Sun and the Moon.

And as we see that one animal naturally generates many animals similar to itself, so the Sun artificially generates Sun by the power of multiplica-

tion of the before-mentioned stone. So it follows that THE FATHER OF IT IS THE SUN, that is, the gold of the philosophers. And because in all generation there must be a suitable and handy receptacle with a certain consonance of similitude with the father, so in this artificial generation it is necessary that the Sun should have a suitable receptacle, consonant with itself, for its sperm and its tincture, and this is the silver of the philosophers. And so it follows that THE MOTHER OF IT IS THE MOON.

Chapter V. That the conjunction of the parts of the stone is called conception.

When these two receive one another in the conjunction of the stone, the stone is conceived in the belly of the wind; and this is why he then says THE WIND BORE IT IN ITS BELLY. It is plain that wind is air, and air is life, and life is spirit—and I have already spoken above of the spirit which vivifies the whole stone. And thus it is necessary that the wind should bear the whole stone and should carry it and should prepare the magistery. And thence it follows that it receives its food from its nurse, that is, from the earth. And so the philosopher says: ITS NURSE IS THE EARTH. For, just as a child without the food of a nurse never becomes of age, so our stone without the fermentation of its earth will never come to the effect, because the ferment is called food. Thus there are generated from one father, with the conjunction of the mother, Things, that is, children similar to the father, which, if they should be without long decoction, will be similar to the mother in whiteness and will retain the weight of the father.

Chapter VI. That the stone is perfect, if the soul is fixed in the body.

Afterwards there follows: THE FATHER OF ALL THE TELESMUS OF THE WHOLE WORLD IS HERE, that is, in the work of the stone is the final path. And note, the Philosopher calls the operation the father of all the telesmus, that is, of all the secret, or of all the treasure, of the whole world, that is, of all stones to be found in this world. It is here. It is as if he were saying, Behold, I am showing it to thee. Afterwards the philosopher says, Look that I may teach thee how the strength of the stone is perfect and complete even though it is turned into earth. And so he says: ITS FORCE IS UNIMPAIRED, that is, perfect and complete, IF IT IS TURNED INTO EARTH, that is, if the soul of the stone itself, of which mention was made above (that the soul in which is the whole life and strength of the stone is called wind and air), is turned into earth, namely of the stone, and is fixed in such sort that the whole substance of the stone becomes one with its nurse, namely the earth, and the whole stone is converted into ferment. As in the preparation of bread, a modi-

cum of ferment nourishes and ferments a great abundance of dough and so changes the whole substance of the dough into ferment, so the philosopher wishes that our stone should be so fermented that it may act as a ferment for the multiplication of the stone.

Chapter VII. Concerning the cleansing of the stone.

Following this he deals with the manner in which it ought to be multiplied. But first he deals with the mundification (cleansing) of the stone and with the separation of its parts, saying: YOU WILL SEPARATE THE EARTH FROM THE FIRE, THE SUBTLE FROM THE DENSE, CAREFULLY AND WITH GREAT INGENUITY. Carefully, that is, slowly, not by violence, but with ingenuity, namely in philosophic manure. You will separate, that is, you will dissolve, because solution is a separation of parts, the earth from the fire, the subtle from the dense, that is, feces and uncleanliness, from the fire, and the air, and the water, and from the whole substance of the stone, so that the stone shall remain without dirt in a state of great cleanliness.

Chapter VIII. That the non-fixed part of the stone ought to exceed the fixed part and ought to raise it.

And the stone so prepared is suitable to be multiplied. And now he deals with its multiplication and with its easy liquefaction by reason of its power of entering both into hard bodies and into soft ones, saying: IT ASCENDS FROM THE EARTH INTO THE SKY AND AGAIN DESCENDS TO THE EARTH. It is to be noted especially that, although our stone is divided in the first operation into four parts which are the four elements as has been said above, there are really two principal parts of it, one which ascends above and is called non-fixed, and the other which remains fixed below, and which is called earth or ferment, which nourishes the whole stone and ferments it as has been said. Indeed it is necessary to have a large quantity of this non-fixed part and to give it to the stone which has been made thoroughly clean from dirt, the whole with magistery, until the entire stone is borne above by the virtue of the spirit, by subliming and making it subtle. And this is as the philosopher says, that it ascends from the earth into the sky.

Chapter IX. How the volatile stone may later be fixed.

Afterwards it is necessary to incerate this same stone, thus exalted, with the oil which was extracted from the stone itself in the first operation, which oil is called the water of the stone, and it is necessary always to roast it by subliming until, by the virtue of the fermentation of the earth carried up with it, the entire stone again descends from the heaven to the earth and remains fixed and fluent. And this is what the philosopher says:

AND AGAIN DESCENDS TO THE EARTH AND so IT RECEIVES THE FORCE OF THINGS ABOVE by being sublimed AND OF THINGS BELOW by being descended. That is, that which is corporeal should be made spiritual by being sublimed, and that which is spiritual should be made corporeal by being descended.

Chapter X. Concerning the fruit of the art and the efficacy of the stone.

SO YOU WILL HAVE THE GLORY OF THE WHOLE WORLD, that is, by this stone so composed you will possess the glory of this world. AND SO ALL OBSCURITY WILL FLY FROM YOU, that is, all poverty and sickness, because the stone so made is curative of all sickness. HERE IS THE STRONG FORTITUDE OF ALL FORTITUDE, because there is no comparison of other fortitudes of this world to the fortitude of this stone. FOR IT WILL CONQUER EVERYTHING SUBTLE AND WILL PENETRATE EVERYTHING SOLID. It will conquer, that is, in conquering it will convert quick Mercury, which is subtle, by congealing it, and it will penetrate other hard, solid, and firm bodies.

Chapter XI. That the magistery imitates the creation of the universe.

Afterwards the philosopher gives an example of the Composition of his stone, saying, SO THE WORLD WAS CREATED, that is, as the world was created, so is our stone made. Because in the beginning the whole world and all that was in the world was a confused mass or confused chaos, as has been said above, and afterwards this confused mass was divided by the artifice of the highest creator into the four elements, marvelously separated and rectified, and because of this separation things were diversified. So divers things can be done by the application of our work through the separation of divers elements from divers bodies. HENCE THERE WILL BE MARVELOUS ADAPTATIONS, that is, if you will separate the elements, there will result marvelous compounds suitable, through the conjunction of rectified elements, for our work in the composition of our stone, OF WHICH, that is, of which marvelous applications to the purpose, THIS IS THE MODE, namely, the given procedure.

Chapter XII. Enigmatic insinuation as to what is the material of the stone.

AND SO I AM CALLED HERMES TRISMEGISTUS. After the philosopher has taught the composition of the stone, he here teaches in an occult manner the things from which the stone is made First naming himself in order that his disciples when they arrive at this science may always recall his name, he then touches upon it, upon the things from which it is made, saying, HAVING THREE PARTS OF THE PHILOSOPHY OF THE WHOLE WORLD. Because whatever is in the world having matter and form is composed from the four elements. Thence there are

infinite parts of the world which all philosophers divide into three principal parts, namely, the Mineral part, the Vegetable, and the Animal, and for these parts, whether joined or separate, the philosopher has the true science in the work of the Sun. And so he says, having three parts of the philosophy of the whole world, which parts are contained in a single stone, namely, in the Mercury of the philosophers.

Chapter XIII. Why the stone is called perfect.

And so this stone is called perfect because it has in itself the nature of minerals, of vegetables, and of animals. For the stone is three and one, triple and single, having four natures, namely, the four elements, and three colors, namely, black, white, and red. It is also called the grain of corn because, unless it shall have died, it remains itself alone. And if it shall have died, as has been said above, it bears much fruit when it is joined in conjunction, namely, in the completed operations abovementioned. O, dear reader, if you know the operation of the stone, I have told you truth, and, if you do not know it, I have told you nothing. IT IS COMPLETE WHAT I HAVE SAID CONCERNING THE OPERATION OF THE SUN, that is, it is complete what has been said concerning the operation of the stone of three colors and of four natures of existence, as has been said, in a single thing, namely, in the philosophic Mercury alone.

APPENDIX 2. *Latin version which appears to be a translation from the same unknown original as that from which the more usual version was made.*

TEXT.

Verum hoc est, & ab omni mendaciorum involucro remotum, quodcunque inferius est, simile est eius quod est superius, per hoc acquiruntur & perficiuntur mirabilia operis, unius rei. Quemadmodum etiam omnia ex uno fiunt, per considerationem unius. Ita omnia ex uno hoc facta sunt per conjunctionem. Pater eius sol est, mater luna, ventus in utero gestavit, nutrix eius terra est, mater omnis perfectionis. Potentia eius perfecta est. Si mutatur in terram, terram ab igne separato, subtile & tenue à grosso, & crasso, & quidem prudenter cum modestia & sapientia. In coelum hoc à terra ascendit, & à coelo rursus in terram descendit, & potentiam ac efficaciam superiorum & inferiorum recipit. Hoc modo acquires gloriam totius mundi: Propulsabis igitur tenebras omnes & caecitatem, haec enim fortitudo omni alii fortitudini & potentiae palmam praeripiens: omnia namque subtilia & crassa duraque penetrare ac subigere potest. Hoc modo mundus hic conditus est & hinc conjunctiones eius mirabiles, & effectus mirandi, cum haec via

sit, per quem haec mira efficiantur, & propter haec Hermetis Trismegisti nomine me appelarunt, cum habeam partes tres sapentiae & Philosophiae universi mundi, consumatum est verbum meum, quod dixi de opere solari.

TRANSLATION.

This is true and remote from all cover of falsehood. Whatever is below is similar to that which is above. Through this the marvels of the work of one thing are procured and perfected. Also, as all things are made from one, by the consideration of one, so all things were made from this one, by conjunction. The father of it is the sun, the mother the moon. The wind bore it in the womb. Its nurse is the earth, the mother of all perfection. Its power is perfected. If it is turned into earth, separate the earth from the fire, the subtle and thin from the crude and coarse, prudently, with modesty and wisdom. This ascends from the earth into the sky and again descends from the sky to the earth, and receives the power and efficacy of things above and of things below. By this means you will acquire the glory of the whole world, and so you will drive away all shadows and blindness. For this by its fortitude snatches the palm from all other fortitude and power. For it is able to penetrate and subdue everything subtle and everything crude and hard. By this means this world was founded, and hence the marvelous conjunctions of it and admirable effects, since this is the way by which these marvels may be brought about. And because of this they have called me Hermes Trismegistus since I have the three parts of the wisdom and Philosophy of the whole universe. My speech is finished which I have spoken concerning the solar work.

APPENDIX 3. *Latin version which appears to be a translation from a different original.*

TEXT.

1. *Verè, non fictè, certò, verissimeque ajo.* 2. *Inferiora haec cum superioribus illis, istaque cum iis vicissim vires sociant, ut producant rem unam omnium mirificissimam.* 3. *Ac quemadmodum cuncta educta ex uno fuere verbo DEI unius: sic omnes quoque res perpetuo ex hac una regenerantur dispositione Naturae.* 4. *Patrem ea habet Solem, matrem Lunam: ab aere in utero quasi gestatur, nutritur à terra.* 5. *Causa omnis perfectionis rerum ea est per universum hoc.* 6. *Ad summam ipsa perfectionem virium pervenit, si redierit in humum.* 7. *In partes tribuito humum ignem passam, attenuas densitatem ejus, re omnium suavissima.* 8. *Summa ascende ingenii sagacitate à terra in coelum, indeque rursum in terram descende, ac vires superiorum inferiorumque coge in unum, sic potiere gloria totius mundi,*

atque ita abjectae sortis homo amplius non habere. 9. *Isthaec jam res ipsa fortitudine fortior existet: corpora quippe tam tenuina, quàm solida penetrando subiget.* 10. *Atque sic quidem quaecunque mundus continet creata fuere.* 11. *Hinc admiranda evadunt opera, quae ad eundem modum instituuntur.* 12. *Mihi verò ideò nomen Hermetis Trismegisti impositum fuit, quod trium mundi sapientiae partium Doctor deprehensus sum.* 13. *Haec sunt que de Chymicae artis praestantissimo opere consignando duxi.*

TRANSLATION.

1. I speak truly, not falsely, certainly, and most truly. 2. These things below with those above and those with these join forces again so that they produce a single thing the most wonderful of all. 3. And as the whole universe was brought forth from one by the word of one GOD, so also all things are regenerated perpetually from this one according to the disposition of Nature. 4. It has the Sun for father, and the Moon for mother: it is borne by the air as if in the womb, it is nursed by the earth. 5. It is the cause, this, of all perfection of things throughout the universe. 6. This will attain the highest perfection of powers, if it shall be reduced into earth. 7. Distribute here the earth and there the fire, thin out the density of this the suavest thing of all. 8. Ascend with the greatest sagacity of genius from the earth into the sky, and thence descend again to the earth, and recognize that the forces of things above and of things below are one, so to possess the glory of the whole world—and beyond this, man of abject fate may have nothing further. 9. This thing itself presently comes forth stronger by reason of this fortitude: it subdues all bodies surely, whether tenuous or solid, by penetrating them. 10. And so everything whatsoever that the world contains was created. 11. Hence admirable works are accomplished which are instituted according to the same mode. 12. To me therefore the name of Hermes Trismegistus has been awarded because I am discovered as the Teacher of the three parts of the wisdom of the world. 13. These then are the considerations which I have concluded ought to be written down concerning the readiest operation of the Chemic art.

Dust Masks for Miners Standardized. Fifty per cent efficiency against tobacco smoke is the standard adopted by the U. S. Bureau of Mines for gas masks to assure protection from smoke and dust.

Many industrial dust respirators and many different fabrics ranging from cheese cloth and absorbent cotton to canton flannel were used in the laboratory tests made by S. H. Katz, G. W. Smith, and E. G. Meiter. Tobacco smoke was used as a criterion because, being excessively difficult to arrest, it affords a severe test for the respirators.

While their use among workers in such dusty industries as mining should be encouraged the tests show that respirators cannot be considered a final safeguard, the experts declare.—*Science Service*

PRACTICAL CHEMISTRY FOR BEGINNERS

H. A. J. PIETERS, ZIERIKZEE, HOLLAND

The Value of Experimental Work

Teachers of science have a great advantage over their colleagues because there is such an abundance of material at their disposal. More especially is that the case with chemistry, which is experimental from the very beginning. It does not leave any doubt that we must try to enable our pupils to perform most experiments themselves, to make them fully acquainted with the methods of chemistry.

In a course in elementary practical chemistry I would distinguish between four general types of experiments. (1) *Experiments illustrating the general course of the teacher*, completed by class-room experiments. In most countries this method is accepted as giving the best results but it is more expensive and gives the teacher more work so that it cannot be done with large classes unless the teacher is aided in his laboratory instructing. (2) *Making preparations* is very useful and stimulating. The student's attention should be guided by questions as is the case in modern manuals. (3) *Qualitative analysis* is a most stimulating intelligence test, especially the preliminary examination of materials when the student is using a self-made system whereby mechanical work should be avoided. (4) Experiments in *physical chemistry* and *simple quantitative problems*.

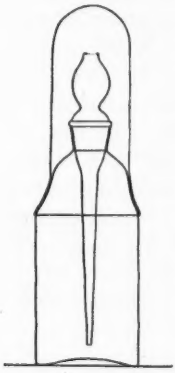


FIG. 1.

As I have already observed it is sometimes difficult, particularly in small laboratories, to follow the experimental method as indicated above. It is possible, however, to perform much of the work with greatly reduced expense for chemicals. This has, moreover, the advantage that rigid economy in the use of materials has an educational value and a remarkable influence on the success of the experiment in general. We need only to transform our methods, making use of the results of microchemical practice. Most analytical reactions can be performed on a piece of glass, porcelain, or paper with minute quantities of reagents. The method enables us to work in small laboratories or even in slightly transformed class-rooms. The necessary solutions can be kept in small bottles provided with pointed glass rods or pieces of small-bore tubing. (Fig. 1.)

The value of experimental work is greatly increased when the pupils are obliged to take notes of the *how* and *why* of each experiment and to give a rational account of it, which should be carefully examined by the teacher. In many cases it saves trouble to indicate the general lines along which this

account should be written. In the following lines I shall further illustrate the foregoing statements from my own experience as a teacher.

Preparations

I need not dwell upon the experiments of the first type, which are to be found in different degrees of usefulness in most text-books and laboratory manuals. Of the preparations I shall give a few examples to illustrate that they furnish practice in chemical calculation. But before I proceed further it will be necessary first to tell you something about working with small quantities.

Salt formation. Necessary materials: microscope, glass slides, equivalent solutions of the most common acids and bases, burner.

On a glass slide the student neutralizes a drop of acid with one of a base after which he carefully heats the resultant salt solution over a small flame until crystallization begins. Then the heating is stopped and when the slide has cooled the residual crystals are examined under the microscope and their appearance portrayed in a sketch as will be seen from the accompanying cuts. (Fig. 2, *a*, *b*, *c*, *d*.) A set of these sketches will enable the student to recognize substances by simple and self worked-out methods. Other salts can be made by dissolving minute quantities of metals and oxides or carbonates in drops of acid. Good results are obtained with sulfates of zinc, copper and iron; chlorides of lead and of the alkali metals; nitrates of sodium and potassium; etc.

FIG. 2*a*.—Crystals of KNO_3.

FIG. 2*b*.—Crystals of $BaNO_3$.

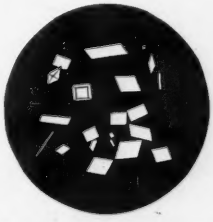


FIG. 2*c*.—Crystals of $NaNO_3$.

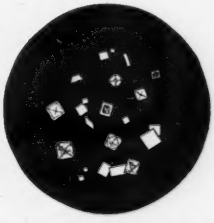


FIG. 2*d*.—Crystals of NaCl.

The reaction of dilute hydrochloric acid on sodium carbonate may be illustrated by dissolving some crystals of sodium carbonate in a test-tube and adding dilute hydrochloric acid. The escaping gas is identified with a drop of a clear calcium hydroxide solution on a glass rod. Then a few drops of the solution in the tube are slowly evaporated as described above and identified under the microscope as sodium chloride.

The crystals of sodium chloride on the slide may be moistened with

concentrated sulfuric acid. The escaping gas is examined: (1) with moist blue litmus paper, (2) with a drop of ammonia on a glass rod, and (3) with a drop of silver nitrate solution. The newly formed crystals may then be dissolved in a few drops of water, evaporated in the usual way and their appearance noted.

Directions for other similar experiments follow:

(1) Mix in a test-tube a concentrated solution of sodium acid sulfate with concentrated hydrochloric acid. What do you observe? Examine the resultant crystals under the microscope and compare with those obtained by treating sodium chloride with sulfuric acid. Conclusion?

(2) Mix a solution of sodium chloride with dilute sulfuric acid and a

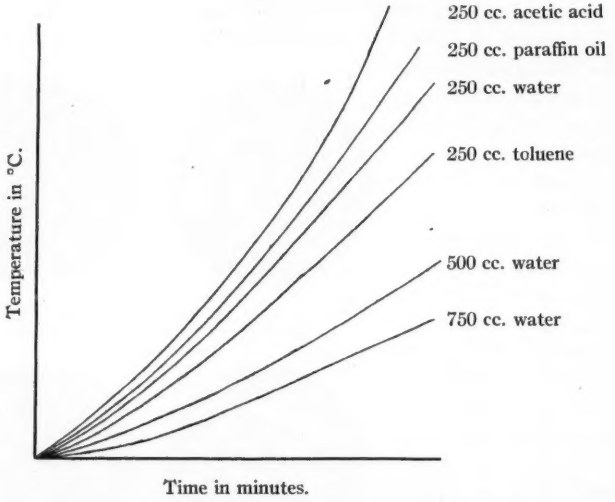


FIG. 3.—Heating of different liquids with constant flame.

solution of sodium acid sulfate with dilute hydrochloric acid. Partially evaporate and examine.

(3) On a slide mix some iron sulfide (previously prepared from sulfur and iron) with a drop of dilute sulfuric acid. The escaping gas is identified with a paper moistened with a solution of lead acetate. The crystals of hydrated ferrous sulfate are examined as above.

(4) Prepare crystals of gypsum in several ways and note their form. Then dissolve some powdered dolomite with hydrochloric acid and add concentrated sulfuric acid. Identify the precipitate.

(5) Prepare crystals of barium nitrate (*e. g.*, from the carbonate with dilute nitric acid). Then add concentrated nitric acid or concentrated

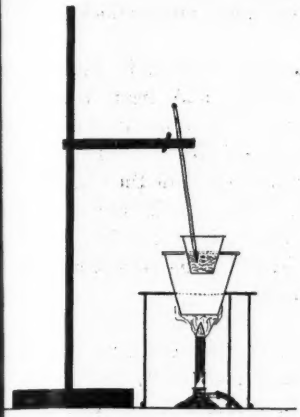


FIG. 4*a*.—Determination of the melting point of tin.

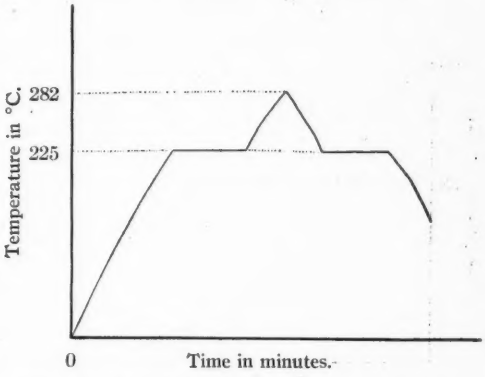
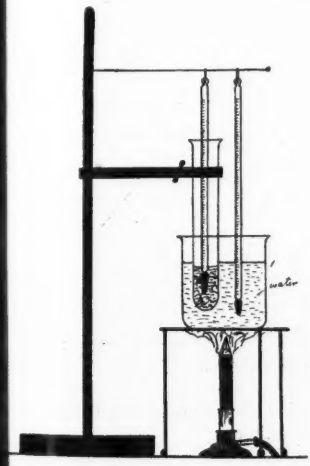


FIG. 4*b*.—Determination of the melting point of tin.

potassium nitrate solution to a concentrated solution of barium nitrate. Examine the precipitate. In the same way precipitate plumbous chloride from saturated solution with sodium chloride; sodium chloride with hydrogen chloride gas, etc. Minute quantities give accurate results.



5*a*.—Determination of the melting point of stearin.

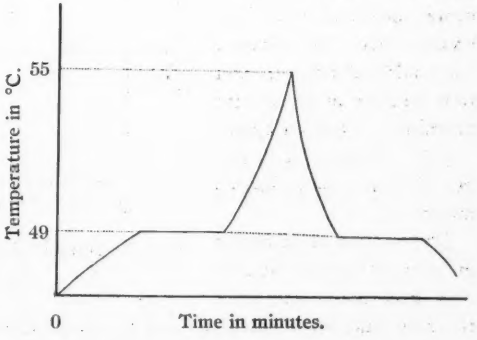


FIG. 5*b*.—Determination of the melting point of stearin.

(6) In the same way trace the reaction products of ammonium chloride with sodium hydroxide.

(7) In a test-tube saturate a solution of potassium hydroxide with chlorine and heat the liquid. Then slowly concentrate a drop of the solution and examine the crystals which precipitate on cooling. They can easily be identified as potassium chlorate.

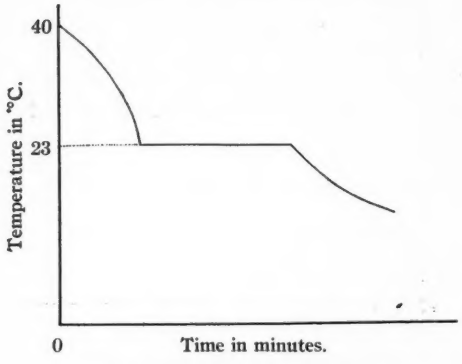


FIG. 6.—Solidification of Cocos Oil.

(8) Neutralize several cubic centimeters of a solution of sodium hydroxide with dilute sulfuric acid, using litmus as an indicator. The acid is added from a burette. Examine the salt formed. Then add the same volume of acid and examine again. Compare with crystals obtained by treating sodium chloride with concentrated sulfuric acid.

(9) Add chlorine water to a solution of sodium acid sulfite and examine. Compare with (8).

(10) Heat some potassium chlorate in a tube with dilute hydrochloric acid and examine.

(11) Prepare potassium bromide from dilute hydrobromic acid and potassium hydroxide. Examine. Then add chlorine solution to a solution of potassium bromide. Examine again.

(12) Prepare a number of double salts in this manner.

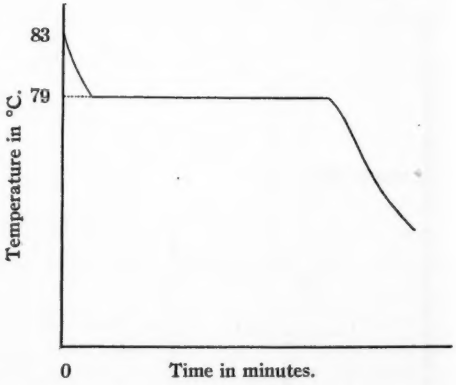


FIG. 7.—Solidification of naphthalene (carried out in a test-tube).

This list can be extended in several directions. I only give some examples to show that most reactions can be adapted to this method. Moreover we can successfully include reactions where a white non-crystalline precipitate is formed. In the case of colored precipitates it is better to use

a piece of filter paper. The results obtained with a drop of each of the reacting solutions are striking. This method of precipitate formation is very sensitive. I use it for the detection of colored sulfides, chromates, hydroxides, ferrocyanides, silicates, etc. However, when the precipitate is crystalline I prefer the method previously described.

I should also like to mention the reactions performed at higher temperatures by melting small quantities of substances on a piece of platinum or porcelain. I recall to you the reaction of lead and saltpeter, the oxidation of chromic oxide, and the formation of potassium manganate. The use of the charcoal block or rod is known to every chemist and I only mention it in passing for the sake of completeness. For the same reason I mention the flame reactions and the formation of borax beads.

It is rather remarkable that the student soon gets so accustomed to this method of testing precipitates that after some time he tries to examine any crystalline reaction product in the described way which has the advantage of requiring only a minimum of time, the slides and microscope always being near at hand.

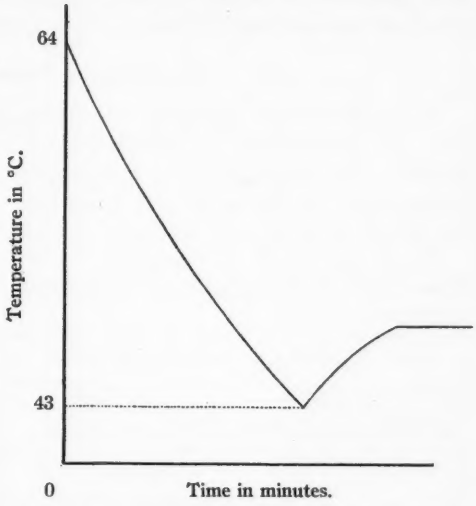


FIG. 8.—Temperature-time curve. Cooling of saltpeter solution.

Other Micro-Reactions

There is another set of reactions which lend themselves readily to observation under the microscope. I mean the decomposition of salt solutions by less noble metals. A thin copper wire in a very dilute solution of silver nitrate gives a fine growing tree of silver crystals. The same reaction can be performed with other couples of metals and much more satisfactorily than in the test-tube.

Applications of the reaction on paper are, *e. g.*, those which the Germans have called "tüpfeln." To mark the end-point of the oxidation of ferrous ion with nitric acid we use a drop of the liquid and a drop of ferrocyanide. The end-point of the reduction of Fehling's solution by glucose is detected with a drop of potassium ferrocyanide, etc.

The organic reactions also give numerous instances where the slide method can be used. I mention the detection of acetates and of acetic acid with silver hydroxide suspension and the formation of normal and acid oxalates and tartrates.

Some electrolyses may also be performed on a drop of the solution on a slip of filter paper. When you, for instance, think of the reaction where a drop of potassium iodide solution serves as indicator of the sign of the electrode, and of the use of a solution of an alkali salt to which phenolphthalein is added for the same purpose, you will agree with me that here lies a possibility of extending these experiments to several other electrolytic reactions, although escaping gases are not detected in this way.

Experimental Notes

The results of the experiments must be described in a short and critical way. It saves time when such an account is made as systematically as possible. To attain that end I recommend giving the student some models of how we desire the work to be done. Such models can be given for several types of experiments. I distinguish the following groups:

General experiments. Description of the problem; general discussion of the reactions; description of the experiment and its results; conclusions; equations.

ANALYSIS

Experiment	Result	Conclusion
Description of substance	Pale green crystals	
Heating in a small tube	The substance partially liquefies; gives off water and ammonia; the color changes to yellow and finally becomes brown-red	The substance is an ammonium compound and contains water of crystallization
Substance heated in borax bead in oxidizing flame	Forms a yellow bead	The substance contains iron
Substance heated with soda in tube	Ammonia escapes (smell; turns red litmus paper blue). No hepar-reaction	The substance contains NH_3
Heated on charcoal after being mixed with soda	Water and NH_3 escape. Residue gives positive hepar-reaction	The substance is a sulfate
Substance with dilute acid		
Substance with concentrated sulfuric acid		
General conclusion: The substance is a sulfate of iron and ammonium, containing water of crystallization. It is a double salt.		

Analytical reactions. These can be described in a very concise manner, which I can best illustrate with some typical examples.

IDENTIFICATION

Substance is dissolved in water and this solution tested with:		
Reagent	**Reaction**	**Conclusion**
Ammonia	Greenish white precipitate which turns green, black and finally brown	The solution contains ferrous ion
Potassium ferrocyanide solution	Blue precipitate	Fe^{++} ion
Barium chloride solution	White precipitate	Sulfate ion

Conclusion: The substance is Mohr's salt: $FeSO_4.(NH_4)_2SO_4.6H_2O$

Equations:

$$FeSO_4 + 2NH_4OH \longrightarrow Fe(OH)_2 + (NH_4)_2SO_4$$
$$FeSO_4 + (NH_4)_2S \longrightarrow FeS + (NH_4)_2SO_4$$
$$(NH_4)_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2NH_4OH$$
$$SO_4^{--} + Ba^{++} \longrightarrow BaSO_4$$

SYSTEMATIC QUALITATIVE ANALYSIS

Description of substance: White powder, slightly soluble in water, soluble in concentrated hydrochloric acid. To this solution are added the following reagents:

Reagent	**Reaction**	**Conclusion**
Hydrogen sulfide	Yellow precipitate	The solution contains ions of the hydrogen sulfide group
To washed and decanted precipitate add some ammonium sulfide	The precipitate dissolves	Tin group
Dilute hydrochloric acid added to this solution	Hydrogen sulfide escapes. Yellow precipitate formed.	
Ammonium carbonate solution	Precipitates dissolves	The substance is an arsenic compound

Conclusion: The substance is probably arsenious oxide.

Identification: The substance heated with charcoal in a tube yields a metallic mirror of arsenic. It dissolves readily in a solution of alkali hydroxide and the resultant solution decolorizes a solution of iodine.

Equations:

$$As_2O_3 + 6HCl \longrightarrow 2AsCl_3 + 3H_2O$$
$$2AsCl_3 + 3H_2S \longrightarrow As_2S_3 + 6HCl$$
$$As_2S_3 + 3(NH_4)_2S \longrightarrow 2(NH_4)_3AsS_3$$
$$2(NH_4)_3AsS_3 + 6HCl \longrightarrow As_2S_3 + 6NH_4Cl + 3H_2S$$
$$As_2O_3 + 3C \longrightarrow 2As + 3CO$$

Whenever *groups of reactions* are to be described this can best be done by tabulating the results. I mention briefly the reactions on ions, description of borax beads, flame reactions, etc. A few examples follow:

EXAMINATION OF SUBSTANCES (IN THE BEGINNING OF THE COURSE)

Description of substance	Shaking with water	Heating with water	Heating with small flame	Heating with larger flame	Conclusion
White, crystalline (saltpeter)	Sinks $d > 1$	Dissolves more rapidly. Solubility increases with temp.	Melts	Gas escapes	Simple substance; decomposes at high temp.
White, amorphous (paraffine)	Floats $d < 1$	Melts. Melting pt. $< 100°C$.	Melts	Decomposes, gases escape, substance blackens	Simple substance; decomposes by heating

EXAMINATION OF ORES

Ore	Description	Heating in tube	Heating on charcoal	Conclusion
Pyrites	Yellow crystalline	Sulfur sublimes. Black residue produces H_2S on heating with dilute HCl. (FeS)	Fragments of iron formed (magnet). Residue gives positive hepar-reaction	Pyrites is a compound of iron and sulfur and contains more sulfur than FeS

In the examinaton of soap prepared by the student I recommend the method which is used in the estimation of the R. M. W. number.

PHYSICAL PROPERTIES

Solubility	Observed facts	Conclusion
In water	Warm water dissolves more soap than cold. This solution is opalescent. By shaking it produces froth. By shaking with oil an emulsion is formed	The solubility increases with temperature. The solution is colloidal and has a great surface tension
After adding the solution of a dye	The precipitated soap is colored	Soap adsorbs the dye

CHEMICAL PROPERTIES

Reagent	Reaction	Conclusion
Ba^{++}	White precipitate	Only the alkali soaps are soluble in water
Fe^{+++}	Yellow precipitate	
Cu^{++}	Blue precipitate	
Pb^{++}	White precipitate	
Mg^{++}	White precipitate	
Ca^{++}	White precipitate	
NaCl Solution	White precipitate	The soap is salted out. It is insoluble in NaCl solution. Surpassing of solubility product
H^+ (Dilute H_2SO_4)	On heating a layer of melted fatty acid is formed which solidifies on cooling	Soap is a salt of a weak acid. It undergoes double decomposition with a strong acid
Phenolphthalein solution	Is colored red	The soap solution gives an alkaline reaction as the soap is partially hydrolyzed, being the salt of a weak acid

The following example describes the reactions of an ion. (Cr^{+++}.)

Reaction on:	Reagent	Result	Conclusion
Cr^{+++}(Solution of chrome alum)	NH_4OH	Green or violet gelatinous precipitate	Chromic hydroxide is a weak and slightly soluble base
	KOH	Green gelatinous precipitate. Dissolves in alkali hydroxide solution. Resultant solution gives a precipitate on boiling or diluting	Chromic hydroxide is amphoteric. Chromites are readily hydrolyzed (differs from Al)
	Na_2CO_3	Green gelatinous precipitate which, after being washed, dissolves in dilute acid without producing CO_2	Chromic hydroxide is formed. The carbonate is completely hydrolyzed
	$(NH_4)_2S$	Green gelatinous precipitate which, after being washed, dissolves in dilute acid without evolution of H_2S	Chromic hydroxide is formed. The sulfide is completely hydrolyzed
	Na_2HPO_4	Green gelatinous precipitate	$CrPO_4$ is formed. It dissolves in dilute acid

The *quantitative experiments* are of special importance. The only drawback is that quantitative work requires more time. Nevertheless much

can be accomplished when all is well prepared and the results obtained with a modest equipment are astonishing. We can choose from the following estimations:

(1) Estimation of density, melting point, boiling point, solubility, specific heat, influence of dissolved substance on melting and boiling point, etc.

(2) Equivalent weights of metals from their action on dilute acids measuring the volume of hydrogen produced. This list can be extended to any length.

(3) Simple gravimetric analyses.

(4) Nearly all volumetric estimations.

I shall again choose some examples from the work of my pupils.

STANDARDIZING DILUTE HYDROCHLORIC ACID WITH PURE Na_2CO_3

		The Na_2CO_3 is dissolved to 100 cc. and 25 cc. of this solution are titrated with the acid.		
			I	II
Wt. of glass + soda:	8.6260 g.	Burette after:	28.74 cc.	28.76 cc.
Wt. of glass:	8.0040 g.	Burette before:	0.00 cc.	0.00 cc.
Wt. of Na_2CO_3:	0.6220 g.	Acid used:	28.74 cc.	28.76 cc.

Calculation:

$$1 \text{ g. mol. } Na_2CO_3 - - 2000 \text{ cc. } N \text{ acid}$$

$$0.155 \text{ g. } Na_2CO_3 - - - \frac{0.155}{106} \times 2000 \text{ cc. } N \text{ acid}$$

$$X = \frac{0.155 \times 2000}{106 \times 28.74}$$

STANDARDIZING BARYTA SOLUTION WITH OXALIC ACID

	I	II
Wt. of glass + oxalic acid: Wt. of glass:		
Wt. of oxalic acid:		
Burette after: Burette before:		
Baryta used:		
Calculated normality: 1 g. mol. oxalic acid—2000 cc. *N* baryta		

QUANTITATIVE ESTIMATION

I. General discussion of method

II. Description of procedure

III. Results

I	II
———————g.	———————g.
———————g.	———————g.

	I	II
Substance weighed	——————g.	——————g.
Crucible and precipitate	——————g.	——————g.
Crucible empty	——————g.	——————g.
Weight of precipitate	——————g.	——————g.
% of.....	——————%	——————%

Simple Calorimetric Experiments*

I. *Determination of specific heat* of a liquid from the rise of temperature when heated with constant flame. The results of this simple determination are shown in Fig. 3.

II. *Mixing definite amounts of water* of different temperatures and determining the final temperature. The first portion of water is stirred in a large beaker. After its temperature has become constant the second portion of higher temperature is poured into the first. The highest temperature attained is taken as final.

W_1	t_1	W_2	t_2	t_e calc.	t_e obs.	Diff.	in %
500	11.2	100	69.1	20.85	20.6	0.25	1.25
600	20.1	100	73.0	27.60	27.3	0.3	1.10
700	26.8	100	69.0	32.10	31.6	0.5	1.50
800	31.0	100	58.2	33.00	33.8	0.8	2.90

III. When we use different liquids this method gives their specific heats.

IV. The same calorimeter is used to determine the specific heats of solids.

V. Determination of the melting point of tin and other substances. Compare Figs. 4, 5, 6, and 7.

VI. Cooling curve for a solution of saltpeter (Fig. 8). As I have already said this list can be extended at will. I hope to have shown in these few examples that much experimental work is possible with moderate means.

* Hellingmann Gondriaan, Praktische Oefeningen in Natuurkunde; Purmerund, Holland.

Lifeless Chemicals Imitate Life Acts. Making lifeless chemicals act as though they were alive is the feat reported from Paris by M. Herrera, a well-known French chemist. M. Herrera made a solution of fourteen parts of caustic soda and one part rhodamine in 100 parts of water, and poured a few drops of this into a second solution consisting of one part olive oil and two of gasoline. The drops staged a close imitation of the behavior of amoebæ, one of the simplest of animal forms. They divided, moved about slowly, elongated, formed vacuoles within themselves and constantly changed their shape. Under proper conditions they kept up this performance for as long as an hour. M. Herrera made no claim that the drops had any properties of life. The phenomenon, he said, is probably due to diffusion currents, changes in osmotic pressure, surface tension, and other physical and chemical influences.—*Science Service*

HONOR STUDENTS IN CHEMISTRY

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The purpose of this paper is to describe the method that is being developed at the California Institute of Technology for dealing with honor students in chemistry. For some years the Institute has been sectioning its freshmen in accordance with their ability. We select about one-fourth of the abler men of the freshman class (which is limited to 160 students) on the basis of their high-school records and recommendations and of an entrance examination testing aptitude rather than knowledge, and further classify these into the best and second best, constituting two sections (A and B), each of 16 to 20 students. We have not attempted to section the remaining three-fourths of the class for the reason that there is not the same need of differentiation in this larger group, more uniform in ability; especially since in our case distinctly inferior students have been much more fully eliminated by the entrance requirements than is usual in state universities or academic colleges. Furthermore, the Institute is especially interested in the abler men, on whom it concentrates its efforts so as to promote their scientific interest and development, under the policy that its primary function is to train scientific leaders, rather than to afford mass education.

The original sectioning based on knowledge available at entrance is readjusted on the basis of work done at the Institute as soon as the first-term records are available; and for the sophomore year and later years the honor sections are made up on the basis of the entire work of the previous year.

The treatment of these "honor sections" has therefore become the most important problem in the undergraduate work of the Institute; and it has been placed in charge of an honor-student committee consisting of representatives of physics, chemistry, geology, engineering, and the humanities.

Before describing the educational side of their work mention may be made of the fact that special efforts are made to afford honor students social and broadly cultural opportunities, and to bring them into touch with research. The honor-student committee entertains once a month at the house of one of its professors the first honor section of freshmen and sophomores (separately), and occasionally takes longer week-end excursions with them to the seashore, mountains, or desert. These students are also invited individually to attend the monthly meetings of Sigma Xi, as well as other lectures describing recent researches.

The nature of the work to be assigned to these honor sections and the methods to be employed in handling them receive constant consideration. These men can accomplish the same work in a shorter time than the average student, both because they have greater ability, and because they have a

better grasp of the work taken previously. Furthermore, if deficient in any topic, they can to a much greater extent be relied upon to work it up incidentally. Many topics that require much drill in other classes can be passed over briefly with these students. They need less drill, less illustrative work, and can take more of the type that taxes logical thinking and ingenuity. They are found to rise to the occasion in a remarkable manner. As one of our teachers has said, "They eat up everything I give them so fast that it keeps me hustling to find anything with which to satisfy their appetites."

A teacher who has been successful with an ordinary class of students may not do particularly well with these students, and one who is not highly successful with the ordinary group may be so with these. Especial pains are therefore taken to assign to the honor sections the best adapted and most inspiring of the teaching fellows.

Various experiments are being tried in the different branches of study of the Institute. In freshman and sophomore mathematics and physics the honor sections omit some of the drill and routine work essential for the average class; and in consequence, in both these subjects, they finish the work in five terms, instead of six. In the sixth term in physics they take a more advanced course called "modern physics," which deals with recent developments in electron theory, radio-activity, and atomic structure. And in place of the regular sixth term mathematics they choose either differential equations or vector analysis.

In chemistry a different plan is followed with the honor students from the beginning. Instead of the general survey of chemistry to which the usual freshman course is entirely devoted, they are given intensive work in its different branches during the successive terms. During the first term they pursue a course in volumetric analysis (including one or two gravimetric determinations); in connection with which in the class-room the principles of stoichiometry, mass-action, solubility, neutralization of acids and bases (including indicators), and oxidation-reduction reactions are thoroughly discussed. In the second term they complete a systematic course in the qualitative analysis of the metallic elements, by which these general principles are further illustrated, and a wider knowledge of inorganic chemistry afforded.

The work of the first term gives the students at the start a quantitative viewpoint of chemistry and a training in exact manipulation, and enables a few principles to be taken up gradually and with thoroughness, instead of overwhelming the student with a mass of detailed phenomena and a larger variety of principles than he can at once fully assimilate. This work, being new to the student and distinct from that pursued in the high school, excites his active interest. Moreover, the analytical work of the first two terms gives the students the back-ground which any chemist

must possess before he can adequately solve even simpler experimental problems; and such problem solving forms at the Institute the main feature of the chemical work of the third term, and also of the sophomore year in case of students who pursue science courses. In the third term of the freshman year each honor student carries on work on a small number of inorganic preparations so selected as to involve reactions of gases, metals, and other solids, rather than solutions (since with the last they have already had sufficient experience). These preparations often involve high temperatures and electrolytic processes. The students are not given routine directions, but, by consulting the literature in the library, they select the best method and plan the detailed procedure, which is submitted to the instructor, and then executed in the laboratory under his supervision. In the class-room the individual students report upon their various preparations. The principles involved are discussed by the instructor, and textbook study of them is assigned; each student being held responsible for a knowledge of all the preparations in progress in his section. Thus the rate and equilibrium of gas reactions, the formation of salt-hydrates, the structure and composition-diagram of alloys, and the laws of electrolysis are always considered in connection with specific preparations.

It is thought that atomic and molecular weight determinations and the physical properties of solutions related thereto usually receive, for historical reasons, an entirely disproportionate share of attention in freshman chemistry. These topics are, therefore, largely eliminated and the defect remedied through a coöperative arrangement with the physics department. In the elementary physics course the gas laws, vapor pressure, boiling point, freezing point, specific heat, etc., are now treated with the thoroughness required by the chemical student and with due regard to their chemical significance.

It is doubtless true that this intensive method of teaching freshman chemistry leads to a less extended speaking acquaintance with chemical phenomena than the usual plan; but it is believed that this is far more than compensated by the thoroughness of the knowledge imparted, the interest awakened, and the originality developed (especially in the latter part of the freshman year and in the courses of the sophomore year). However, to meet the criticism of narrowness, the intensive plan is supplemented by a course of semi-weekly demonstration lectures, which are attended by all students, not only those of the honor sections.* In these lectures, no

* At the Institute twelve hours a week (including the outside study required) are assigned to freshman chemistry. Of this, two hours is given to the lectures and two hours to outside reading upon them. Two 3-hour periods are assigned to laboratory work and one hour to class work. The remaining hour is available for outside study, the student being free to use laboratory time for library work, planning experiments, writing up of reports, etc. Honor students are encouraged, but not required, to spend a third 3-hour period in laboratory.

attempt is made to cover the field of chemistry systematically, as is commonly done; but each lecture (or short series of lectures) is devoted to some topic of especial theoretical or practical interest; for example, to metals, combustion, catalysis, colloids, photography, atomic structure, periodic system, radio-active elements, crystal structure, organic structure theory and important organic compounds, plant and animal metabolic cycles, nitrogen fixation and fertilizers, electrolytic and electrothermic processes, important chemical industries, etc. These lectures, which are given in turn by the various members of the chemical staff, are independent of the rest of the work, whether of the honor or regular students, are supplemented by the requirement of outside reading on the respective topics, and are made effective by mid-term and final term examinations separate from those given on the rest of the work. Their purpose is, however, not to give detailed information; but to afford a survey and appreciation of the science in its broader aspects, including its research side, and thus inspire the student, and really interest him in science and research.

At the end of the freshman year prize scholarships (carrying half-tuition for the next year) are awarded to the ablest six or eight students in the first honor section (irrespective of financial need); and these students are given the opportunity of devoting the first three or four weeks of the summer to a minor research problem in inorganic or physical chemistry.[1]

At the beginning of the sophomore year all Institute students choose between its two four-year courses of study—in engineering or in science, the last of which prepares for graduate and professional work in chemistry, physics, mathematics, geology, chemical engineering, electrical engineering, and engineering research.[2] The students taking the engineering course have only one more term of chemistry, which consists in a treatment of the important aspects of engineering chemistry from broad theoretical standpoints. All students in the science course have at least two years more of chemistry, while those preparing for chemical or chemical engineering professions continue chemical subjects through the undergraduate course. The

[1] Thus, last year two students prepared $(NH_4)_3AlF_6$ and $(NH_4)_2SiF_6$, which were needed in a research in progress in the laboratory upon crystal structures, whose significance was explained to them. Another studied the lead-thallium alloy diagram—so effectively that a short paper describing the work upon it has been prepared for publication. Two others began an investigation of the vapor-pressure of salt-hydrates (such as $ZnSO_4.7H_2O$) by a new method consisting in bringing them into equilibrium with boiling alcohol, and determining the water-content of the distillate by density measurements. Another studied the hydrolysis of salts of weak acids at 100° with the aid of indicators; and others determined by potentiometer measurements the behavior of oxidizing and reducing agents under certain standard conditions.

[2] It is perhaps of significance that, though in general about two-thirds of all the students select the engineering course, 13 of the 14 students in the first honor section who last year had freshman work substantially as above described chose to enter the science course.

honor students in science, who alone concern us here, take work as follows. They are given in the analytical laboratory during the first term some additional practice in gravimetric and qualitative analysis (especially in relation to acidic constituents and rare elements). Then during the second term they take up a research problem in connection with the working out of the system of approximate quantitative analysis which is being developed by Dr. E. H. Swift, who is their instructor. Each student is assigned one of the common elements and is told to study the analytical literature and devise the volumetric method by which the precipitate obtained in the usual qualitative scheme can be best analyzed to determine its approximate quantity. After criticism by the instructor, he proceeds to test out this process in the laboratory. In the class-room each student occasionally presents his plan and results to his fellows.

In the third term of the sophomore year honor students who are preparing for chemistry or chemical engineering continue their analytical research problems or undertake new ones more on the physico-chemical side; while students entering other options of the science course take one term of class work and laboratory in organic chemistry. Throughout the junior year all science students take a thorough course in chemical principles (physical chemistry); and those in honor standing, preparing for chemical work, take a research in this subject in the third term.

Old German University Plans Big Celebration. The picturesque old University of Marburg, in the German province of Hessen-Nassau, is getting ready to celebrate its four hundredth birthday next summer by inviting universities all over the world to send representatives to the party. The event is expected to be of world-wide scholastic importance.

Marburg University was established in July, 1527, by the Landgrave Philip of Hessen and was the first German university founded after the Reformation. Two of its most famous professors have been the chemist, Robert Bunson, inventor of the Bunsen burner," and the jurist von Savigny. Since 1866 the university's status has been similar to a combination of a state university and a land grant college in the United States.—*Science Service*

Rubber Block Pavement Successful in Boston. Tests on rubber block pavement, laid one and one-half years ago at the entrance to City Hospital in Boston, have shown marked advantages. In addition to having worn but little during the interval, the pavement has the advantage that snow and ice do not collect on it in winter as on other types of pavement, thus doing away with slipperiness. The blocks are also almost noiseless and vibrationless.

These rubber paving blocks are an invention of R. F. Herrick, a consulting engineer of Boston. They are made largely of reclaimed rubber. Those used in the present test are 12 by 6 inches in area and 2 inches thick, and are laid in plastic sand and cement directly on the street foundation. Their edges were given a coat of asphalt paint immediately before laying.—*Science Service*

AN ADVANCED CHEMISTRY COURSE IN A HIGH SCHOOL

OSCAR R. FOSTER, MANUAL TRAINING HIGH SCHOOL, NEW YORK CITY

The term "Advanced Chemistry" as here used means a course of instruction in qualitative analysis and industrial processes; this subject-matter is not usually found in elementary text-books on chemistry. Such a course has been successfully given in the Manual Training High School, Brooklyn, New York, for over ten years. I shall discuss the content and method from the standpoint of experience and conviction rather than give a statistical resumé.

The time allotted to advanced chemistry is one school year (40 weeks). One term (20 weeks) is devoted to inorganic qualitative analysis; the succeeding term (20 weeks) is devoted to industrial processes. It is the latter which I shall describe.

A modern high-school chemistry course must serve two purposes: first, it must give a minority of students a firm foundation for further work in college; second, it must give a large majority of students sufficient chemical information to serve as a useful part of their knowledge equipment for life. I believe that the course in industrial processes adequately serves both objectives.

The topics treated are:

I. Unit Processes.
   - Crystallization (including the use of solubility curves)
   - Distillation (discussion of one form of still which includes dephlegmation)
   - Evaporation (one form of evaporator discussed)
   - Filtration (filter press, leaf filter, continuous filter)
   - Lixiviation
   - Pulverization (jaw crusher, rolls, ball mill, etc.)

II. Inorganic Industries.
   - Glass
   - Nitric Acid (Birkeland-Eyde process)

III. Organic Industries.
   - Gas (coal gas, water gas)
   - Glycerine
   - Leather
   - Paper
   - Soap
   - Sugar

IV. Metallurgical Industries.
   - Aluminum (Hall's process)
   - Copper

Iron (pig iron, wrought iron)
Lead
Silver (Parkes' process)
Steel (Bessemer, open-hearth, crucible)

As now given the course always includes all the unit processes; however, it cannot include all of the industrial processes. Therefore, a selection is made; each term the industries chosen are somewhat different from those of the preceding term. The following selections for the current year are typical:

Fall term 1925	Spring term 1926
Unit processes	Unit processes
Nitric acid	Glass
Paper	Paper
Aluminum	Aluminum
Leather	Leather
Soap	Crucible steel
Silver	Soap

The mode of instruction is quite different from that which is usually employed in secondary schools; it is a lecture-recitation method. This has proved to be admirably adapted to the course. The instructor describes the process under discussion, and places upon the blackboard sketches and sectional drawings of the apparatus which is used. The chemistry of the process is carefully explained; in addition the strictly mechanical manipulations are dwelt upon. All subject-matter is recorded by each student in a note-book together with a copy of each of the sketches and drawings mentioned; to this is added dictated matter at the discretion of the instructor. The note-books are given critical examination periodically.

During explanations the students ask questions and ample time is allowed for general discussion; voluntary questions are encouraged. As the course progresses these discussions increase in frequency and interest.

At the close of the formal discussion of a process the students are quizzed; they are required to reproduce black-board drawings as well as give verbal explanations. As soon as one process has been entirely reviewed the next one is begun.

The text-book used is "Outlines of Industrial Chemistry" by Frank H. Thorpe[1] from which are assigned lessons to be studied. In the school library are encyclopedias and other reference books; important among these is "Elements of Industrial Chemistry" by Allen Rogers.[2]

The verbal instruction is supplemented by illustrative material. Hand samples of both raw materials and finished products are brought to the class-room; also mounted photographs are passed from hand to hand.

A museum for hand specimens is maintained. Suitable material is

[1] The Macmillan Co., New York.
[2] D. Van Nostrand Co., New York.

added from year to year. Samples of raw materials and manufactured products are constantly on exhibition in well-lighted cases which are located in one of the halls. Figure 1 shows one section of the museum cases. Figure 2 is a closer view of three of the shelves. The specimens are

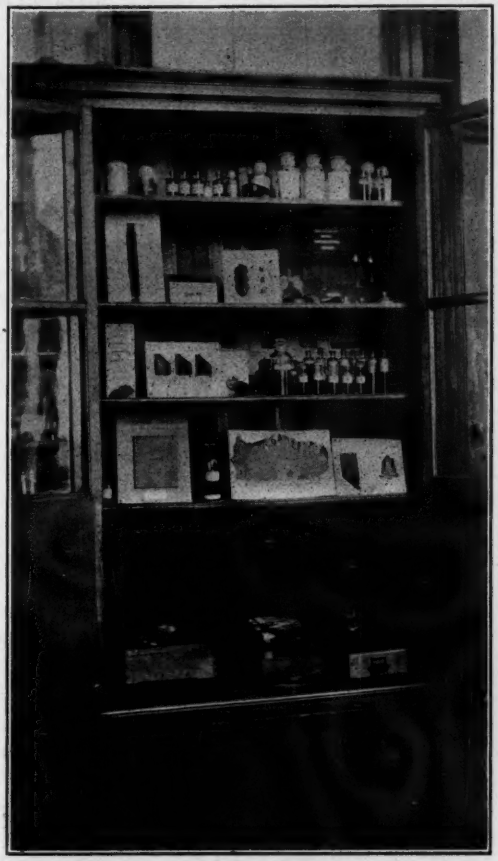

FIG. 1.—Section of school museum.

fastened on thick white cardboard whenever practicable, a convenient and inexpensive mount.

After the study of a process has been completed, lantern slides are shown to illustrate factory methods.

Several times during the term the class is taken on inspection trips to industrial plants in the city and vicinity. Fortunately the metropolitan

area affords a wide variety of establishments suitable for such trips. During the past few years plants have been visited which produce leather, shoes, glass, clocks, soap, drop forgings, paper, gas, and sugar. The firms engaged in these lines of manufacture have shown a gratifying willingness to extend courtesies to advanced chemistry classes; this arises from a sense

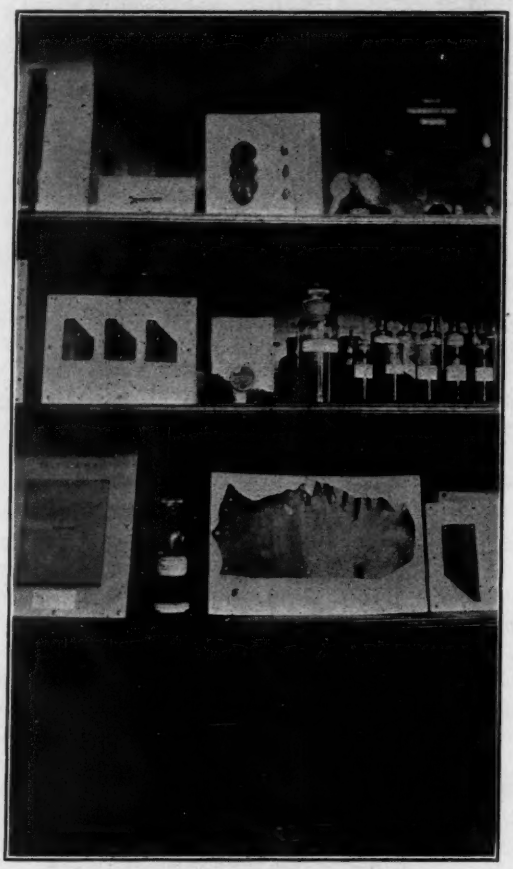

FIG. 2.—Close-up of three shelves.

of public service and a sympathetic attitude toward the work of the schools. In certain industries inspection trips are regarded as having advertising value.

The entire course in advanced chemistry (qualitative analysis and industrial processes) is elective. Therefore a select group of students whose interest is sustained throughout the school year is secured.

ILLUSTRATING THE BLACK ART

(Suggested Methods for a Demonstration of Alchemy)

R. D. BILLINGER, LEHIGH UNIVERSITY, BETHELHEM, PA.

"Plays the alchymist,
Turning with splendour of his precious eye
The meager cloddy earth to glittering gold."

The spirits of Hermes, Geber, and Paracelsus can be induced to return and exert their influence in the present day. The traditions of chemistry, with all the weird mysticism of old alchemy, can be taught in no better way than by performing some of the old tricks and reading the old recipes. The alchemist, with his knowledge of herbs and oils, his tricks of legerdemain, and his smattering of philosophy was able to fool both rich and poor alike—and frequently himself.

Imagine yourself in the year 1350 A.D. in the Court of the Good King Leopold, when the following announcement is heralded:

"Tonight, before his Royal Highness, the noted Alchymist Martano will make fire with ice, create snakes from dust, turn water into wine, communicate with departed spirits, and many more wondrous things."

The effect was awe-inspiring. Everyone came to see this man of supernatural power and wisdom. His feats are still a source of entertainment in a day when we no longer accept them as miraculous.

The author has been able to instruct and entertain by a simple program of chemical tricks done in the role of an alchemist. The accompanying pictures show "The Alchemist" (Fig. 1), according to Teniers' conception, and (Fig. 2) the author in his impersonation of Paracelsus. The list of symbols here shown (Fig. 3) is the best known of the large collection of characters handed down by the alchemists.

An outline of the performance follows:

The curtain rises on the scene of a dingy old laboratory in which there is a large collection of antiquated chemical apparatus. There is a central table on which the tricks are performed. Martano appears as an old hermit. He has long gray hair and beard and is attired in monk's costume. He totters forward saying:

"O, ye generation of unbelievers. Ye, who scoff at true philosophy and alchymy, shall this night see great wonders. If the stars are favorable we shall communicate with Hermes and see the image of the Philosopher's Stone."

"Now concentrate all eyes on this most bright of fires and presently an image shall appear."

At this point Martano lights a strip of magnesium wire which burns with dazzling brilliance. Simultaneously the other lights are extinguished and the magnesium flame is intensified. When it has burned out there is

a brilliant after effect left on the eye for several seconds and the audience focuses its attention at this point. Meanwhile Martano substitutes a

FIG. 1.—"The Alchemist," as conceived by Teniers.

death's head painted with luminous paint, or a solution of yellow phosphorus in olive oil. The lights are still out and Martano holds the skull

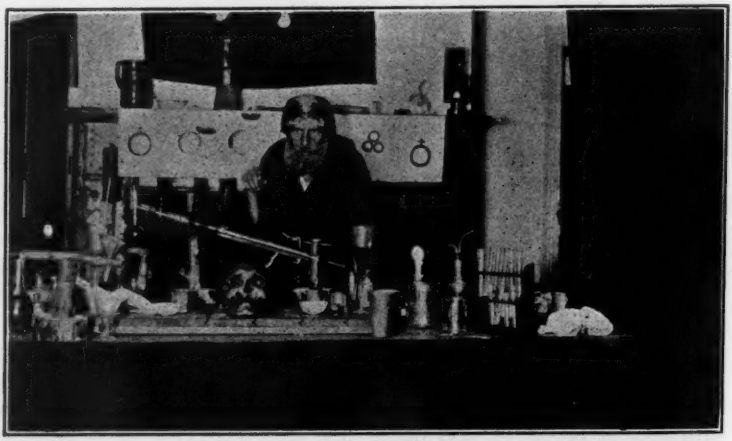

FIG. 2.—"The Alchemist" as impersonated by the author.

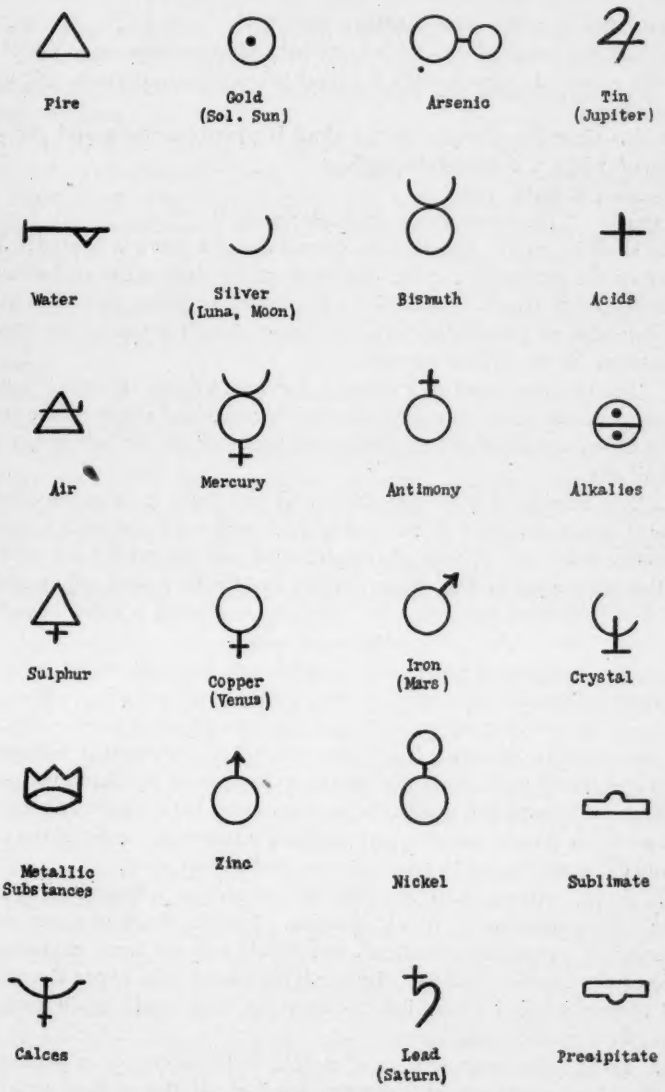

FIG. 3.—Symbols of alchemy.

in the position where the magnesium wire was burned. The effect is a gradual one on the eye, changing slowly from a shapeless form into the outline of the skull.

While this is proceeding Martano says:

"Behold the image of the Stone in its hazy phosphorescence. The stars are with us and the time is right for great projections. Hermes, wilt thou to us appear?"

By this time the phosphorescent skull is plainly evident and the jaw is moved while a confederate replies:

"Hermes is with you."

Martano: "Then will we to our task repair."

The skull is quickly removed or covered and the room is lighted. The speech of the alchemist can be developed *ad lib.* during the performance of the following tricks. Suffice it to say that everything should be made as mysterious as possible and the alchemist should preserve the utmost seriousness in displaying his art.

1. The effective stunt of starting a fire with ice can be done if a little sodium peroxide has been placed on a bed of paper and sticks. The application of the wet ice starts an immediate flame which can be kindled into a small fire.

2. The turning of wine into water and vice versa is an application of suitable indicators while dilute hydrochloric acid is treated with a sodium carbonate solution. If both phenolphthalein and methyl red are used the solution will be red at first, then colorless and finally a deep red on adding sufficient carbonate solution. By carefully regulating a series of goblets the "wine" or "water" color can be obtained.

3. The creation of pyrotechnic snakes can be done either with the prepared "Pharaoh's Serpents" or with freshly made samples. These are obtained by first mixing concentrated solutions of ammonium sulfocyanate and mercuric nitrate. The white precipitate obtained is filtered off, dried and mixed with about one-fourth its volume of powdered potassium chlorate. To form the powder into cones use a little alcohol to moisten and make the powder plastic. By applying a match to the tip of the cones the magic snake begins to grow, squirm, and appear alive.

4. Secret writing with invisible ink is always interesting. This is done with a solution of cobalt chloride. Several sheets of paper should be carefully prepared beforehand and should contain some characters in code or alchemistic symbols. By applying heat to the paper the writing will appear in distinct reddish brown color, which will again disappear after the hydrated salt forms.

5. For a fake transmutation of metals, strips of copper or pennies can be placed in a solution of mercuric chloride. If this is done in a glass battery jar the color change from copper to mercury will be quite evident. Surface changes on metals often convinced the alchemists that transmutation was possible.

6. The generation of flame by simply waving paper in the air will

mystify your audience. The paper should be a large filter paper which has been wet with a solution of white phosphorus in carbon disulfide. The carbon disulfide quickly vaporizes and the phosphorus ignites the paper in flame.[1]

7. A candle can be mysteriously lighted by applying some of the solution mentioned in the preceding trick to the candle wick. In order to extinguish the flame in an equally mysterious way, pour some carbon dioxide from a large transparent bottle down over the candle. Apparently nothing has been poured, but the candle is quickly extinguished.

8. A beautiful violet colored flame can be made by mixing finely ground potassium permanganate with glycerine. By regulating the amounts of permanganate, the height of the flame and the time of its duration can be governed.

The object of this article is merely to suggest the outline of procedure. The number and variety of the tricks may be varied by the performer to suit the occasion. The production of all sorts of color changes and odors, varying from sweet smelling perfumes to the disgusting odor of valeric acid, can be produced if one wishes to employ a few organic compounds.

References should be made to the symbols of the elements during the performance and their connection with the planets.

If time is available several old recipes should be read from the literature of alchemy. Two very humorous ones are given here.

From Brearley's "Heat Treatment of Steel."—

"To harden tools for working stone, a three-year-old he-goat should be taken and tied up for three days without food. On the fourth and fifth days it is to be fed on fern leaves and nothing else. On the following nights it is to be allowed to stand in a tub, and the urine, which runs through a hole in the bottom of the tub, falls into an empty bucket. When after two or three nights a sufficient quantity has been collected, the goat is released and the tools hardened in the urine."

Also from Van Helmont's "The Causes and Nature of Fever."—

"One heats in a brass pan $1^1/_2$ oz. of turpentine of cyprus and then introduces fifteen live spiders and mixes until the spiders have disappeared; one then places the whole on the fire and continues to stir, introducing as many cobwebs as the spiders would presumably have spun, or, if cobwebs are lacking, one adds nine other small spiders and agitates further; one then adds $1^1/_2$ oz. of good asphalte and 1 oz. of white sal ammoniac, and allows to cool until one obtains a paste which is allowed to stand for fifteen days. Meanwhile one prepares a special oil in the following manner: One mixes oil of fresh water-lily flowers, one-year old, with oil of bitter almonds; nine live scorpions are then introduced and the whole is exposed

[1] The greatest caution should, of course, be observed in performing phosphorous tricks.

to the sun when this is in the constellation of the Virgin or of the Crab, and it is left thus until the scorpions are dead; 1 oz. of pastel of female vipers is then added and it is left in the sun for a further fifteen days. The oil is then ready. An hour before the fever appears one ties two of these ointment preparations to the wrists of the patient and leaves them for exactly nine days, takes them off at the same hour as which they were applied and throws them into running water. Whatever be the nature of the fever, after this cure it will disappear."

Claims Invisible Germ Killer Is Living, Breeding Organism. "The bacteriophage is alive." So maintains Dr. F. d'Herelle, its discoverer, fronting the skeptical criticism of many other men of science, in his new book on the subject just off the press. The bacteriophage is alive and no mere chemical phenomenon; and it maintains itself, he says, as a parasite of parasites, a deadly submicroscopic germ that kills other germs. No culture of bacteria can be "pure," as far as the bacteriophage is concerned; it is harder to find a germ without its bacteriophage accompaniment than it is to find a woolly dog without fleas in summer.

But the bacteriophage is not a mere annoyance to the germs it infests, according to Dr. d'Herelle. It kills them, just as some germs kill men and animals and plants, and then it dissolves their corpses. And just as there are special germs that attack men and not horses, and others that attack horses and not sheep, so there are special breeds of bacteriophage, each of which has its favorite germ which it attacks. But just as some germs, for example anthrax, will attack men, horses, and sheep indiscrminately, so there are some varieties of bacteriophage whose appetites are equally indiscriminate, permitting them to devour several different species of bacteria. Dr. d'Herelle claims that he has succeeded in isolating single bacteriophage "corpuscles," and in breeding up pure cultures of these different strains.

According to the author, these "super-germs" are almost unimaginably small, having diameters of 20 thousandths of a thousandth of a millimeter—and a millimeter is about a twenty-fifth of an inch. They pass readily through the pores of a very fine porcelain filter that will stop ordinary germs as though they were marbles in a colander. But one of these tiny organisms, he says, will penetrate into the body of a bacterium, and there will divide and divide again, just as a germ does in the body of a man; until the bacteriophage "family" becomes so numerous as to burst the unfortunate bacterium asunder and so cause its death.

Man and all other animal organisms habitually infested with bacteria carry about with them all the time one or more strains of bacteriophage that make war on their commonest germ enemies. When the germs get the upper hand of the bacteriophage, we are sick; when we are convalescent, Dr. d'Herelle says, our private bacteriophage strains are in a state of especial virulence against their special germ victims.

Dr. d'Herelle made his discovery of the bacteriophage while he was at the Pasteur Institute in Paris. He is now at Alexandria, Egypt, working on problems of the control of tropical diseases. The use of the bacteriophage for combating tropical plagues was forecast in literature before it was actually attempted in practice, for the hero in Sinclair Lewis' novel, "Arrowsmith," is sent on an expedition to a Caribbean country to put down an epidemic.—*Science Service*

ORIENTATION OF STUDENTS IN CHEMISTRY: APTITUDE AND PLACEMENT TESTS AND RESULTS IN FIRST YEAR CHEMISTRY*

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General Conditions

Chemistry, at present, is under the fire of criticism, constructive and destructive. Yet it is undoubtedly taught as well on an average as any other subject. Personally I am convinced that there is a tendency to include too much relatively unimportant matter in our chemistry and other texts, and displace those essential fundamentals which make for a lasting foundation and for interest in the subject. Are our text-books as suitable as they were twenty or thirty years ago? I think they are not from the inductive teaching viewpoint. Are the younger teachers and students, as an average, working as hard on the subject-matter as did teachers and students a few decades ago? I think not. There are more outside things to be done today. Are the overhead duties and assigned extra curriculum activities smothering the real interest in and effective teaching of chemistry? Yes, it is evident to a large number of teachers that there is much energy and time needed for questionable or even unessential activities. Habit and popularity, however, require the teacher to "follow the crowd." Are there not too many efforts to standardize measurement of results of learning in chemistry? There appear to be, because conditions and types of students vary too widely. There are also some who believe that because laboratory technic and ingenuity are not measurable by so-called standard test questions that the laboratory should be abolished.

On the other hand, are present-day students in college and preparatory school as well prepared as formerly, on an average? I do not think so, but some students, teachers, and investigators think so and that they know the proper topics, procedures, etc., for all. They do not, they have simply stopped thinking about the subject.

Preparation for College

University and college teachers often decry the lack of preparation of many students entering upon collegiate work. The high- and preparatory-school teachers look upon the raw material they receive as unprepared. Primary school teachers consider poor work or lack of previous training or information as due to the home from which the child comes. With compulsory primary and partly compulsory secondary education as the law of our government, we must, in the final analysis, decide to do the best we can under the circumstances. These, then, are the conditions and problems met with and I will consider a few of them.

* Paper read before joint meeting of Divn. Chem. Educ. and Section of History of Chemistry of A. C. S. at Tulsa, April 6, 1926.

Admission to the University of Maine

At Maine, and conditions there are similar to conditions in most other state universities, admission is almost entirely by certificate from secondary schools, mostly from within the State. The number of students admitted by examination can be disregarded. Is the certificate method better than examination? I believe most teachers who have had to deal with both forms prefer the examination procedure (if they do not have to grade a lot of papers themselves) or at least the comprehensive type of entrance examination with a graduation certificate or other evidence. A reasonable examination is no great burden for students desiring to enter college if they have had conscientious preparation involving themselves and their teachers. Likewise, all college teachers know that the principal of a high- or preparatory-school cannot easily avoid granting a certificate to children of prominent residents of his community for political and many other reasons. He is often between two fires. He may give a certificate when he should not and the boys or girls may then make a poor showing when they undertake first-year college work. If he does not consider the pupil worthy and refuses to give a graduation certificate, the pupil's parents want to know why, with results frequently unpleasant to the principal. This is especially the case where pupils have a very good time in general and in extracurricular activities and a very poor one at study or in classes and when their parents have pictured them as future college graduates.

The present procedure at Maine is to admit students with certificates on trial if they have a percentage record about five to ten units above and, regularly, students who have a standing ten units or more above the record rewarded by a certificate of graduation. These figures are varied slightly. This procedure has improved preparation for college and reduced the shrinkage where the shrinkage was due to poor general preparation. This seems a desirable procedure where it is applicable. It aids the principal of the preparatory school as well as the university and the student.

It is generally admitted that there is a wide variation in (*a*) natural aptitude and interests of secondary-school pupils, (*b*) teachers, their qualifications and interests, and (*c*) facilities available for satisfactory instruction. In addition, the teaching staffs of the smaller secondary schools undergo frequent changes. Before the college assigns courses for students, should candidates not be subjected to a test as much as are men, materials, and energy in industry? To operate at least with some effort at economy it is undoubtedly desirable to orient the incoming freshman. To do this, it is well for students entering college without entrance examinations to have brief tests as to their general aptitude and their ability to express their acquired information in at least a few fields. Then after a few weeks, if conclusions from records check with entrance tests, is it not our duty to endeavor to direct unqualified students away from work in which they are

very likely to be unhappy and unsuccessful? With the present tendency toward an effort at segregation of students into groups based on ability, it would seem that either an entrance examination or an aptitude or aptitude and placement test becomes necessary. With personnel records additional to the scholarship records, administrative officers can judge students much more accurately.

Why a Freshman Week?

This question has often been asked of teachers at Maine. If new students come to a college and after a hurried registration are set to work, they frequently start in the wrong field. Talks as to the work of engineers, language teachers, scientists, foresters, etc., frequently disillusion the young mind. All freshmen need such talks by the persons best qualified to give them as early as possible during the year or at a time devoted exclusively to freshmen and their needs. The question of freshmen becoming acquainted can usually be left to care for itself. One very helpful feature of a special time for freshmen to register is to avoid the rush met with in registering a student body of about three times as many students.

In past years psychological and other tests were given to all members of the freshman class at Maine during regular sessions. It was impossible to obtain all of the students at one time, therefore, a series of examinations was needed and the regular work of the students was interrupted. Now a time is available for all such tests in the special freshman week. At some institutions a shorter period than a week might be more suitable for these purposes.

Courses in General Chemistry for Freshmen

With the average college, two courses in general chemistry are the limit as to cost. This arrangement meets the needs on the basis of recognizing the chemistry work of a preparatory school when well done, and provides a different type of work with different text, and with a different kind of laboratory work (inorganic preparations, etc.), along lines which do not duplicate any of the student's previous chemistry. No other correlation between preparatory-school and college chemistry seems to meet all requirements. All of our first-year students are given work in the elements of qualitative analysis during the last quarter of the college year.

In our freshman college chemistry, all general freshmen are enrolled in four lecture groups scheduled at different times. The advanced general chemistry group (ten to twenty per cent of the total) has lecture, laboratory, and recitation periods which coincide with one of the four general chemistry groups, making possible the transfer of a student from advanced general to general chemistry without involving other departments. For a few years, at the time of registration, staff members of the

chemistry department were assigned to question registrants, examine evidence of previous training and determine if a student was qualified for the advanced course. Prior to 1920 all students who had received admission credit in chemistry were placed in the advanced group. Over fifty per cent were then in the wrong place. See articles by H. S. Fry[1] and F. E. Brown.[2] In a few cases students had had only demonstrations and no laboratory work. The present procedure of subjecting all members of the incoming class to a brief printed aptitude (A) or aptitude and placement (B) test at the same time in groups in different places with strict time limits is very satisfactory. The Iowa type of test, much abbreviated, is used. Forty minutes were allowed last September as total time for parts A and B. Students who had no previous chemistry took the aptitude test only, then when the time limit for A was reached they left, their papers being collected. Students with previous work in chemistry then took the chemistry test (B) also with a time limit. All work was done on the question paper furnished, and, with a point value printed for the question, grading was easily and quickly accomplished by a few departmental staff members. Our advanced general chemistry group is selected very satisfactorily now. Information as to the student's preparatory school, his teacher in chemistry, text used, course or college which the student has selected or in which he will enroll, is obtained on these papers which become a part of the student's departmental record. All freshmen in the College of Technology and in the College of Agriculture are required to take general chemistry. Some students enrolled in the College of Arts and Sciences elect no chemistry in their freshman year. They often appear, however, in later years, and their aptitude or placement record is then noted on their general chemistry record.

Cost and Results

Is this work and slight expense, either to the student or the institution, warranted? I thoroughly believe that it is.

The efforts to correlate results of aptitude and placement tests with those of the students' work in general chemistry have been very satisfactory. Almost all of the entering freshmen, over four hundred in number, were enrolled in one of the two general chemistry courses. Some changed their course or college to eliminate required general chemistry. Others, whose aptitude tests indicated that a study of matter and its changes was hopeless, were obviously failures in general chemistry in a few weeks. When the first half-semester records were available, many were dropped from chemistry classes, or if they met with much difficulty in other departments, also from the university.

[1] THIS JOURNAL, **2**, 260–9 (1925).
[2] *Ibid.*, **3**, 301–6 (1926).

The test paper given in September, 1925, was divided into four parts. Section A (Parts I and II) on aptitude was taken by all freshmen; section B (Parts III and IV) on chemical information and training was taken, in addition, by students who had studied chemistry in high school. The average percentage results for section A only, were, girls 68.5; boys 75.5; which agrees in general with the fact that boys, on the average, are naturally more interested in and experienced with matter and its changes. For the combination of sections A and B, averages obtained were 65.7 per cent for the girls, and 70.7 per cent for the boys.

Six students in 410 failed to obtain 50 per cent on the aptitude test. Three of these did not enroll, two were dropped from chemistry at the end of the first half semester, and one has maintained a margin of one or two per cent above the minimum passing grade. For the sections A and B on aptitude and information and training, sixteen students failed to obtain a grade of 50. What became of these? Four did not enroll for chemistry, and one left shortly after enrolment due to sickness. Of the remaining eleven who completed the first semester's work, two failed, one received a condition grade, five received passing unsatisfactorily grades (60-69), and three received passing grades (72, 74, and 76). These three students came from high schools having good preparation records and were those with test grades only slightly under 50 in the aptitude and placement test. Of these students, by the end of the first half of the second semester, the student with the condition grade was dropped from chemistry. Of the five who passed unsatisfactorily, one went backward to a condition grade and the other four maintained the same status. Of the three who received passing grades, two advanced a few per cent and one dropped to the passed unsatisfactorily grade. Students who showed up well in the aptitude test only or in the aptitude and information and training test, maintained good records with very few exceptions. A study of the few students who had no laboratory work but received entrance credit in chemistry, based on lecture demonstrations, etc., showed them to be failures. This leads to the conclusion that individual laboratory work is very important.

Records of Major Students

Three curricula have been offered at Maine for many years; B.S. in Chemistry, B.S. in Chemical Engineering, and B.S. in Chemical Engineering (Pulp and Paper Division) all in the College of Technology. The work is the same for all three groups in the freshman year and is essentially the same as that of the other courses in the College of Technology. A course leading to the B.A. degree in Chemistry is also given but as freshmen in the College of Arts and Sciences do not enroll for major work until the beginning of the sophomore year, they will not be considered.

Twenty-eight freshman students enrolled for chemical engineering

and twelve for chemistry courses in September, 1925. All but six of these had had preparatory-school chemistry. This is desirable. Those who did not have preparatory-school chemistry are all good men, two having honor grades in general chemistry. These facts indicate that many boys start their life work with the right vision, interest, and natural qualifications.

The division of these forty students on the basis of records in the placement test was about equal between the general (Ch. 1) and advanced general chemistry courses (ratio Ch. 1 to Ch. 3::22:18). Two with quite low records have changed major departments. All of the others, with but one exception, have maintained satisfactory records for three-fourths of the work of the year. The exceptional case noted, upon analysis, showed that the student obtained aptitude and placement test grades relatively low for this group although there are hopeful signs that he will pass the course and begin the next year's work. For procedure in arriving at results see THIS JOURNAL, **2**, 566 (1925).

During the second year's work, results, especially in analytical chemistry, physics, and second-year calculus, make possible the elimination from this group of major students, any who are definitely in the wrong field of work. Some will be advised to make changes to other departments if they do not have a drop record for their college. During the junior and senior years there are but very few students who change their major departments from chemistry and chemical engineering to other fields.

Departmental records of students after graduation, show that very few engage in activities other than those having to do, at least to some degree, with chemistry or chemical engineering.

Conclusions

Where college entrance examinations are not available an aptitude and placement test is very helpful in grouping freshmen into a large general chemistry group and a small group of well-prepared students, ready to undertake a slightly different type of work avoiding duplication of good preparatory work in chemistry. This proportion of each group will, of course, vary with time and place. Students who will probably have difficulty in a course can be determined and either given additional work without credit or placed in a separate group. Additional evidence is obtained upon which students can be better oriented in selecting their future occupations on the basis of their natural and acquired ability and information.

The criteria of the value of school education will be the extent in which it creates a desire for continued growth and supplies means for making the desire effective in fact.—DEWEY.

AN APPLICATION OF COLLOID CHEMISTRY TO LUBRICATION

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In connection with his work on the utilization of artificial graphite, which he was capable of producing on a vast commercial basis, Dr. Edward Goodrich Acheson, by a process which he termed "deflocculation," succeeded in colloidalizing graphite and suspending it in both oil and water mediums. This method was a direct development of his work in 1901 when he found a means of improving the plasticity of clays[1] by a colloidal process which, however, was not recognized as such at that time.

The colloidal graphite suspensions have long been articles of commerce and are marketed under the names of "Aquadag" and "Oildag." The former is used extensively in lubricating the diamond dies employed in wire drawing, while the latter has wide application in general mechanical lubrication.

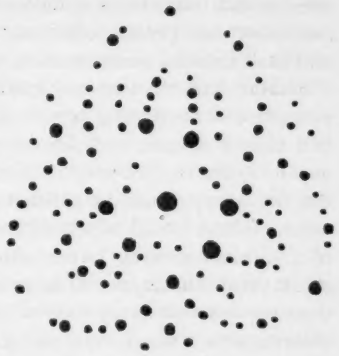

FIGURE 1.

To explain the lubrication efficiency of colloidal graphite in oil, one might start with the seemingly remote subject of crystal analysis.

Laue conceived the idea of using a crystal as a grating in connection with X-ray study. The crystal was used as a substitute for the usual line-ruled grating employed to set up diffraction effects as obtained with ordinary light. He found that when a pencil of X-rays was directed against a crystal, the reflected rays, which were permitted to impinge upon a photographic plate, formed a symmetrical pattern. (Fig. 1.) Laue interpreted this as a method of studying the orientation of atoms in crystals and formulated a theory in this connection. W. L. Bragg revealed

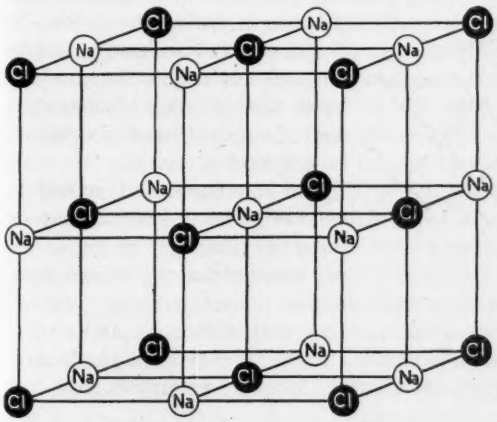

FIGURE 2.

certain errors in Laue's theory and subsequently offered a theory of his own which has proven to be accurate, and which makes possible the determination of crystal structure from the diffraction pattern.

The structures of numerous compounds have been studied. Sodium chloride, or table salt, has been found to consist of planes of atoms equidistant from each other, in which the sodium and chlorine atoms are situated alternately and so spaced as to constitute a lattice. The small cubes, formed by the intersection of planes (Fig. 2), have four atoms of sodium and four atoms of chlorine alternating at their corners. This arrangement causes each sodium atom to be surrounded by six chlorine atoms, and each chlorine atom, in turn, to be surrounded by six sodium atoms.

Sodium and chlorine are known as monovalent elements or elements possessing a combining power of one. Langmuir[2] calls attention to the fact that if sodium and chlorine possessed only their primary valence of one, a crystal of rock salt could not exist, as the entire combining power of the two atoms would be utilized in the formation of individual salt molecules. These would be wholly free and unattached because of the absence of additional binding forces. Inasmuch as effort is required to break a salt crystal, binding forces are certainly existent within the mass. Langmuir reasons that every sodium atom must have affinity for each of the six chlorine atoms which surround it, and in a similar manner, every chlorine atom has like affinity for its sodium neighbors. This affinity is described as secondary valency. In view of these conditions, Langmuir concludes that a molecule is as large as the crystal, as it is evident that no particular affinity exists between any specific pair of sodium and chlorine atoms. It is only on vaporization that the atoms reveal their usually accepted, or primary, valency to form what is generally defined as a molecule. Since the atoms, during the process of evaporation or condensation, have different valency relations and have altered their "molecular" state, Langmuir considers these to be chemical processes.

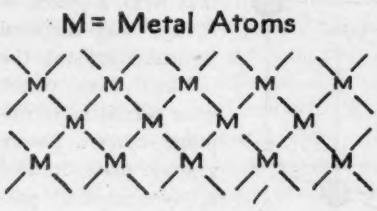

FIGURE 3.

The distribution of secondary valency forces in a metal may be shown as illustrated in Fig. 3. It will be noted that the surface atoms must necessarily create a stray field for their excess secondary valency or cohesion bonds. It is on this ground that adsorption and surface tension have been looked upon as chemical, rather than physical phenomena. Some startling data[3] verifying the chemical nature of adsorption have been published.

Colloidal suspensions of graphite in oil may be obtained wherein the

suspended graphite is as high as 50%, however, for all practical purposes, a graphite content higher than 0.35% is needless. The minute particles, which Freundlich[4] found in many cases to be less than 500 millimicrons, are susceptible to being readily adsorbed, especially by metal surfaces seeking to satisfy their surface energy. The graphite particles, because of their smallness, possess a huge surface for their mass, which, too, is rich in surface charges. A magnet of insufficient strength to lift a piece of metal is capable, because of its own energy, of adhesion. Similarly, colloidal graphite, in exercizing its surface energy, adheres to (or is adsorbed by) a metal surface whose mass may be infinitely greater.

Graphite is a lubricant. Adsorbed graphite, while retaining its ability to lubricate, as tests later to be cited will show, possesses one of the fundamental properties of an efficient lubricant—the ability to saturate the surface forces of the bearing. Hardy[5] is the authority for the statement that "the function of a lubricant is to reduce the energy of the surface and thereby to reduce the capacity for cohesion and the resistance to slip when two composite surfaces are applied the one to the other." He[6] further states that the friction of two clean surfaces is due not to the surfaces but to the adhesion between them. A film of oxide or sulfide on a surface of copper acts as a very effective lubricant owing to the lowering of the surface energy of the copper. Hardy[7] concludes that the adsorption of the lubricant by the solid appears to be a controlling factor. The better lubricant is the one more adsorbed by the solid.

Wells and Southecombe[8] found that by adding a small amount of a fatty acid to a mineral oil a much improved lubricant was obtained. Archbutt and Philip,[9] in a discussion on the "germ process" as Wells and Southecombe term their methods, endeavored to explain the action of the fatty acid in terms of adsorption. Archbutt suggested that Deeley, in a communication to the Physical Society, expressed the probable effect when he said that the unsaturated molecules of the lubricant united with the solid metal surface and formed a new surface which opposed less resistance to shear than the unlubricated metallic surface. Philip expressed the belief that metallic soaps were formed by the action of the fatty acids on the metal bearings, and being formed at the interface of oil and metal, were adsorbed by the latter. Philip found in practice that after substituting mineral oil for a pure sperm oil, in a certain instance, that flakes of oleates and stearates of copper and iron were freed from the bearing surfaces. Upon the removal of these soaps an increase in the coefficient of friction resulted. The importance of adsorption is thus emphasized.

In the discussions pertaining to graphite-oil suspensions, the adsorbed film is usually referred to as the "graphoid surface." In practice, employing the usual 0.35% suspension, a suitable surface may not be formed until after 1000 hours of use. A graphoid surface is essential to reduced friction

and may be quickly obtained by painting the friction surfaces with a $12^1/_2\%$ graphite suspension. After the graphoid surface has been formed, a 0.35% suspension of colloidal graphite in oil may thereafter be substituted, as its graphite content is sufficient to maintain the graphoid surface.

"Oiliness" is an essential property of a good lubricant. Many attempts have been made to determine just what is necessary to promote "oiliness." Wells and Southecombe feel that by the "germ process" the "physical rationale of the property of oiliness is now explained" and give as grounds for their belief, the decrease in interfacial tension between the fatty acid bearing oil and the metal surface. They say "the permanency of films is dependent upon a diminished interfacial tension between the oil and the metal in contact therewith. If such a film is broken the possibility of its uniting again to form an unbroken layer depends entirely upon the interfacial tension being low. Any substance which lowers the interfacial tension causes the liquid to spread over a larger area of the solid. It follows, therefore, that if a substance be added to an oil which brings about a lowering of interfacial tension, such addition will act favorably as far as lubrication is concerned by preventing a rupture of the liquid film, and preventing, in turn, the metals coming into direct contact."

If the spread of liquid over a surface is indicative of interfacial tension, the tension at the interface of graphite and oil is lower than at the interface of metal and oil. A simple test consisting of the dropping of oil from the same tip on both a piece of clean metal and a metal surface bearing an adsorbed graphite film will prove this. So that the drops may be of uniform size, they should be permitted to form from the same tip very slowly and for the same period of time. Permitting drops to run on these surfaces placed at the same angle will also show the graphoid surface to be more freely wetted by oil.

With the proper use of oil carrying colloidal graphite in suspension, it is quite impossible for the metal surfaces to come into contact and seize. The metal surfaces are isolated from each other by two graphoid surfaces, each of which is an excellent lubricant in itself. These surfaces in turn are themselves protected by a graphite bearing oil which, because of the low interfacial tension existing at the adsorbed film, insures the thorough "wetting" which is so essential in efficient lubrication.

Mabery[10] made a series of interesting tests with graphite suspension which very convincingly show the superiority of colloidal graphite lubrication. Mabery states: "Of all known materials the substance graphite alone possesses the qualities of a normal lubricant. In its ordinary natural condition it is not possible to mechanically subdivide it so completely that it can penetrate the fine interstices of metallic surfaces and at the same time form a persistent coherent lubricated surface; but in a form of complete purity, free from the mineral constituents of natural graphite and in

a condition of minute sub-division, such as is formed by the conversion of Acheson's electric furnace graphite into its colloidal condition, there is available a solid lubricant that fulfils the requirements of economic lubrication. It is so finely divided that it readily permeates metals and by reason of its unctuous quality its own friction is reduced to a practically negligible quantity, thus escaping the internal friction of oil lubricants that is an important factor in the losses of power."

"Fig. 4 shows the coefficients of friction extending through the period of the test (two hours) and also that the oil film broke seventeen minutes after the supply was shut off.

"Fig. 4 also presents the curve for the same oil carrying 0.35% graphite under the same elements of pressure, speed, and supply of oil to the

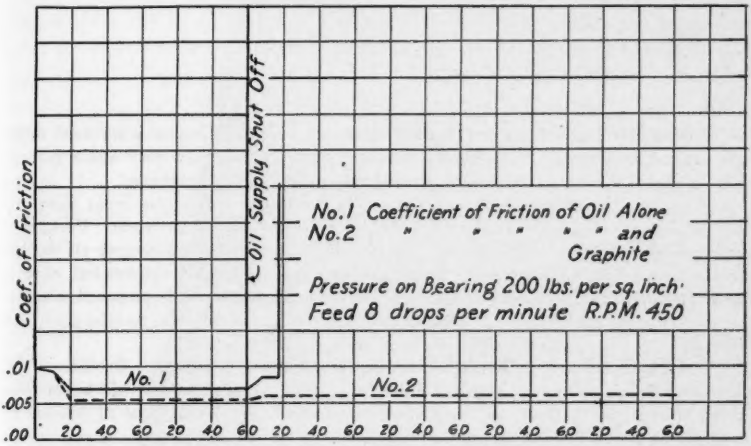
Coef. of Friction
Oil Supply Shut Off
No.1 Coefficient of Friction of Oil Alone
No.2 " " " " " and
Graphite
Pressure on Bearing 200 lbs. per sq. inch
Feed 8 drops per minute R.P.M. 450
.01
.005
.00
No. 1
No. 2
20 40 60 20 40 60 20 40 60 20 40 60 20 40 60 20 40 60

FIGURE 4.

bearing. The low coefficient of friction is apparent which, with a corresponding lower temperature, indicates clearly the influence of the graphite, * * * * * but the observation of especial interest in this test is the permanence of the graphoid surface after the supply of lubricant was discontinued."

Saytzeff[11] found that after the bearing surfaces had secured the adsorbed graphite, the friction decreased approximately 30%. In all cases the addition of 1 to 2% of graphite suspension resulted in an appreciable reduction in oil consumption.

The results of these investigators are borne out in practice where the reduction in the coefficient of friction is reflected in power bills as well as in a decrease in oil consumption. Crystal analysis—remote from colloidal

science as it may appear—has aided much in the theoretical consideration of the efficiency of colloidal graphite lubrication.

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[5] *Phil. Mag.*, **38**, 32 (1919).
[6] *Proc. Roy. Inst. Gt. Br.*, **1920.**
[7] *Phil. Mag.*, **40**, 201–11 (1920).
[8] *J. Soc. Chem. Ind.*, (1920); or *Chem. News*, **120**, 244 (1920).
[9] *Chem. News*, **120**, 269–70 (1920).
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[11] *Z. Ver. deut. Ing.*, **58**, 358–9 (1914).

Cheap Germicide for Honeycomb Found. Honeycomb in a hive afflicted with the ancient bee disease of foulbrood can be disinfected and used over again just as health officers fumigate a house where there has been a case of diphtheria.

This bee disease which attacks the young bee larvae and causes great losses to the beekeeping industry was known as far back as the days of Aristotle. Formerly, in order to make sure of checking its spread, the beekeeper had to destroy all the infected combs and hives by fire. Now, however, experts at the agricultural experiment station at the University of California have found that an easily prepared solution of soap, water, and formalin is a cheap and effective agent that will sterilize even the interstices of the hexagonal cells of honeycomb.—*Science Service*

French to Hold 50th Scientific Meeting and Industrial Exhibit. Exhibits of all that French scientists are doing in the field of pure and applied science will be on view at the fiftieth congress of the French Association for the Advancement of Science to be held at Lyon, France, beginning July 24th.

The meetings will be presided over by Dr. Alfred Lacroix, the permanent secretary of the French National Academy of Sciences, in the exposition building of the city of Lyon, which offers unique advantages for displaying the numerous exhibits. The wide range of the whole congress over the fields of chemistry, physics, medicine, the biological sciences, sociology, and in fact everything of an industrial, practical, or theoretical nature that comes within the scope of science, is expected to attract the presence of experts from all over Europe.

Papers will be read summarizing results of French scientific research in every line from the latest cancer treatment to teaching peasants modern methods of farming. Guests at the congress will have opportunity to see places of widely varying scientific interest in which the region around Lyon abounds under the guidance of the scientists who know most about them. Excursions have been arranged to visit, among other places, Solutre, one of the famous sites where remains of men of the stone age have been unearthed. A typical stratum will be shown to visitors and explained by Prof. C. Deperet, of the department of geology at the University of Lyon. Chief among the places of interest to workers on industrial problems will be a trip to the hydro-electric factories of the upper Rhone.—*Science Service*

THE VALUE OF TESTS IN WRITING CHEMICAL EQUATIONS

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The Chemistry Involved in Chemical Equations

In the last few years much has been done to establish certain fundamental objectives which high-school chemistry teachers should consider as a basis for instruction. An excellent advance in the right direction has been made in a report on topics for a Minimum High-School Course in Chemistry,[1] prepared by the Committee on Chemical Education of the American Chemical Society. One of the topics referred to as essential is, "Equations and their use in expressing chemical changes, including gravimetric and volumetric equations." It is obvious that ability to express chemical reactions by means of chemical equations cannot be acquired until the pupil has gained a good working knowledge of symbols, formulas, and valence. Ability to write chemical equations precedes an ability to solve problems involving weights of substances and volumes of gases concerned in chemical reactions. To identify the kinds of chemical changes, such as direct combination, decomposition, simple replacement and so on, it will greatly help if these changes are expressed as chemical equations. The writing of these equations with the attendant problems involved, assumes considerable chemical knowledge of such matters as atomic weights, molecular weights, symbols and formulas, valence, percentage composition, and the hypotheses of Avogadro and Gay-Lussac. To write chemical equations correctly, foretells a knowledge of the behavior of the substances interacting or undergoing a chemical change and vice versa. Students must be familiar with the chemical conduct of the substances, to adequately express this conduct through chemical equations. Inability to write chemical equations probably presupposes ignorance of the chemical behavior of interacting substances. Chemical change and chemical knowledge of it, together with the ability to express chemical change by means of chemical equations, are doubtless interdependent.

In other words, chemical equation writing becomes one of the fundamental requisites of any chemical course. No student can gain a true understanding of chemistry until he can think in terms of atoms and molecules and can so express himself and interpret these concepts in chemical equations. It is one of the concepts of any chemical course, satisfactory for students who wish a general knowledge of chemistry as well as for those who are going to college. Its value for expressing chemical change has steadily progressed. As soon as chemical symbols came into being, they were used to interpret chemical combinations, advancing into use for the interpretation of chemical reactions. However, our secondary-school chemistries contain so many chemical equations of varying degree, that

[1] THIS JOURNAL, **1**, 87–99 (1924).

the average teacher merely refers to them, utterly ignores the greater part, or finds it impossible to teach the pupil to write many of them. At least, for the less experienced teacher, it is a problem to know what chemical equations the pupil should be required to write correctly and what are non-essential.

No Uniformity of Chemical Equation Content in Text-Books

To support the contention that our secondary school chemistries vary in the number of chemical equations emphasized by authors, it is interesting to note that in an analysis made by Dr. D. A. Prescott of Harvard University, of six most commonly used secondary-school chemistry texts, the number of equations occurring in the several books examined, varied from 205 to 785, with a total of 2607 equations occurring in all six texts. The number of different equations found in each of the six books ranged from 196 to 500. A total of 1117 different equations existed in the six texts. Thus, it becomes a distinct problem for teachers to know what equations to emphasize, particularly when the book they may be using is one containing 500 to 785 different equations. Inability of high-school pupils to express chemical reactions by means of chemical equations is more likely to be common than uncommon. This condition may be the result of poor teaching; the mentality of the pupil; failure on the part of the teacher to diagnose and emphasize the important reactions; failure to consistently use equations; failure to begin the rudiments of equation writing early; failure to teach valence and chemical combination properly; and similar conditions. H. L. Gerry[2] remarks that, "an examination of test papers reveals difficulty with equations. It would seem as if the principle of equation writing might be taught so that every student after a year of study would be able to write the equation for such a simple reaction as sodium on water. Do we not need to explain again to them the principle of equation writing and give them drill in the process?"

Advancing further with the study made by Dr. Prescott, it was determined that the number of like equations occurring in all the books was only 34, and the number occurring in four of the examined texts was 129. Since 129 equations were found common to four of the texts, it may be safely inferred that every pupil, who has studied chemistry for a year, will have come in contact with at least a greater part of these and may be accordingly held responsible for properly completing them. Consequently, three tests were constructed from the 129 equations. One thousand pupils were examined in each test. The tests were then scored carefully and the equations arranged in order of difficulty as determined from the scores of the students tested. From the equations of these preliminary tests, evaluated as to difficulty, two new forms were constructed

[2] "What Are We Teaching in Chemistry?" *Sch. Sci. Math.*, **24**, 361–6 (April, 1924).

and called "Achievement Tests in Chemical Equations." Each form contains fifty equations and thirty minutes are allowed to complete each.

Results from the preliminary testing brought out several noteworthy features. There exists a wide variety of pupil ability in equation writing, which indicates that the importance of this phase of chemical training is either not sufficiently emphasized, poorly taught, or regarded as not too important. Good results were as regularly obtained from small schools as from the large ones; likewise poor responses were common to both. On the average, there is little difference, apparently, in the quality of this part of chemical teaching, from either the town or city high school, though the larger high schools ought to be getting the better results through their ability to employ better trained teachers. In several hundreds of the tests, the yearly average of the pupils in chemistry was recorded, so that the individual scores could be correlated with the general chemical knowledge of each. As might be expected, ability to write chemical equations correctly correlates highly with general chemical knowledge. An excellent or good student in chemistry normally will write chemical equations well and the reverse is likewise true. Thus, one may quite safely predict standards in chemical equation writing commensurate with general chemical ability. It would not, however, be safe to say that standards of ability in chemical equation writing predict general chemical knowledge.

The Teaching of Chemical Equations

The teaching of chemical equations is not ideally standardized among teachers. Methods must be adapted, somewhat, to pupil ability. The application of the electronic theory of valence to the writing of chemical equations has been advocated. However, equation writing at best is difficult for the average high-school pupil and it is doubtful if much of the electronic application will prove helpful or inspire pupils in the mastery of its technic for some little time to come. Clear, forceful, simplified teaching probably is the most efficient. It is certain that equations can never be written by memorizing them, for it is impossible to remember the number that is needed in the average course. Forgetfulness of the slightest detail means a failure in the equation and it will tend to discourage rather than encourage a fondness for chemistry. The science of the task must be developed and certain knowledge fore-gained concerning the reacting substances before chemical equation writing becomes easier and before pupils feel confident in their ability to write them.

Chemical equations are based on the law of conservation of mass. They are likewise dependent on facts which the chemist knows through experimental evidence. Equations can be assembled in a mechanical fashion, but they have no value unless they represent true atomic disturbances, or what the chemist may be able to procure. For instance, it is perfectly

possible to balance an equation using fluorine and oxygen, but since no oxide of fluorine is known, such an equation has no value; it is not experimentally true. Suppose a pupil has prepared hydrogen from the interaction of dilute hydrochloric acid and zinc. He realizes experimentally that the reacting substances have formed hydrogen as one of the products and is told to express his results in the form of an equation. He is quite likely, as a beginner, to set down a sort of skeleton equation as $Zn + HCl \longrightarrow ZnCl + H$. Though it apparently conforms to the law of conservation of mass, the study of valence has taught him that zinc is divalent and requires two univalent chlorine atoms. Thus his second step becomes, $Zn + HCl \longrightarrow ZnCl_2 + H$. Valence in each instance is satisfactory, but the law of conservation of mass has been destroyed. If he writes next, $Zn + HCl_2 \longrightarrow ZnCl_2 + H$, it is not true, for hydrogen is never divalent in the hydrochloric acid molecule so that two molecules are required and the last step is represented by the equation, $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$. Consequently, in four successive steps, the equation representing the reaction of zinc and hydrochloric acid has been made to fulfil all the requirements of the experimental data and balance.

Again, hydrogen is a good reducing agent, being oxidized to water in the presence of hot copper oxide. The student has discovered this experimentally and proceeds to write, $CuO + H \longrightarrow H_2O + Cu$. As previously described he makes adjustments so that it becomes, $CuO + H_2 \longrightarrow H_2O + Cu$.

Since equations have both a quantitative and qualitative significance, it is excellent practice to encourage the pupil at the outset to place the molecular weights beneath each reacting substance, and if not previously studied, it prepares the way for the determination of molecular weights, percentage composition and calculations by the use of equations. Students may obtain an excellent drill in balancing equations by teachers building up equations in the following manner,

$$NaCl + H_2SO_4 \longrightarrow \_\_\_\_ + Na_2SO_4$$
$$HgNO_3 + \_\_\_\_ \longrightarrow HgCl + HNO_3$$
$$BaO + \_\_\_\_ \longrightarrow Ba(OH)_2$$

Equations, purposely made incomplete, may be given for pupils to balance properly, such as,

$$Fe + O_2 \longrightarrow Fe_3O_4$$
$$SO_2 + O_2 \longrightarrow SO_3$$
$$2KClO_3 \longrightarrow KCl + O_2$$

Some teachers do not use equations at all, except word equations, during the greater part of the year. When pupils have some first-hand knowledge of a few cases under the laws of definite and multiple proportion, the Daltonic hypothesis is introduced. Applications of Gay-Lussac's law may

follow and then Avogadro's hypothesis. In this way the pupils are led up to formulas and equations in what some chemistry teachers like to call a "human process." A student brought up under such a system of chemical training is quite sure to know why H_2 is written on the right-hand side of an equation rather than 2H.

Thus constant and varied drill in the development of chemical knowledge tends toward positive constructive attainment in equation writing. To write equations well and consistently correct, students must be trained to "think chemically." Whatever may be said about various devices for writing equations by means of ions, the application of the electron theory, and graphic schemes, it is probably safe to infer that except under an inspired teacher working with a superior group of students, very little success can be obtained in the use of such methods, until the average pupil has attained a good working knowledge of the more simplified methods of equation writing. A high-school student should be able to ionize simple equations as well as understand the graphic scheme before completing his course. However, if we take our more popular high-school chemistries as guides, the evidence is strongly opposed to trying these newer ideas before the easy, fundamental steps have been comprehended. In the last analysis, teaching equation writing is the individual problem of every teacher. No matter how many methods may exist, class skill in this phase of chemical training must be attained in the most direct, the simplest, and withal the most permanent manner, depending on the aptitude of the pupil.

Public Slow to Benefit by Great Medical Discoveries. That the great medical discoveries made by doctors and research workers should be more fully applied, so that the public may benefit by them, was urged by Miss Elizabeth G. Fox, director of public health nursing of the American Red Cross, who spoke at the second Pan American Red Cross Conference in Washington recently.

When the germ of some dread disease is isolated, the public shows great enthusiasm, and at once mentally checks that disease off as "conquered," Miss Fox told the conference. In reality, however, the new knowledge cannot work any magic in the world until it is the property of the man in the work shop, the mother in the home, the school teacher, and the child on the playground.

The public health nurse was described by Miss Fox as the agent that is needed to work among the people in their homes, to teach them the value of disease prevention and modern medicine, to help them to get proper medical attention, and to build up for them an ideal of health.

"In this country it is estimated that only ten per cent of the sick are cared for in hospitals," said Miss Fox. "The remaining 90 per cent are cared for in their homes, and of this 90 per cent perhaps less than a quarter can afford the services of a private nurse. The majority of them, and this includes people of moderate means such as professional people and those in small business, must depend upon the services of a public heal nurse if they are to have skilled nursing care."—*Science Service*

A DETERMINATION OF THE SCIENTIFIC ATTITUDES

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Introduction

The literature relative to the teaching of science, and the formal addresses, the conferences, and the conversations of teachers of science are plentifully sprinkled with vague and veiled allusions to the "scientific attitude." Each mention of this "scientific attitude" conveys the tacit inference that every teacher possesses, as a matter of course, a clear idea of the precise meaning of the term.

But a painstaking search of the literature fails to reveal a single instance where an author attempts a clear-cut definition of the "scientific attitude," or where an author gives a reference to such a definition in any other source. There is frequently manifested, moreover, a confusion of the concept of the scientific method with that of the "scientific attitude."

An attempt to construct a statement of the "scientific attitude" from the various references and allusions to it at once reveals the fact that in the minds of the different authors there is no *unit* concept of scientific *attitude*, but that there is a more or less nebulous and illy differentiated group-concept of scientific *attitudes*.

Problem

This investigation[1] represents an attempt to secure a list, as complete and as definite as possible, of the scientific attitudes.

Method

An extensive investigation was made of the scientific literature dealing with the philosophic phases of scientific thought, such, for example, as Pearson's "A Grammar of Science," Dewey's "How We Think," Kramer's "The Method of Darwin," etc., for the purpose of securing a list of scientific attitudes. The search revealed a considerable number which in outline form were submitted to fifty high-school and fifty college and university teachers of science. These specialists were requested to mark "E" each item which they considered an essential one in a complete list of scientific attitudes; to mark "D" each item which they considered highly desirable but not essential; and "U" each item which they considered unnecessary or undesirable in such a list. The markers were invited to write in such changes and corrections as they thought desirable, and to add any omitted points or items which they considered essential.

Fifty-eight replies were received; two were returned unclaimed.

[1] This investigation is one of several, complete accounts of which the author has included in "Some Values Derived from Extensive Reading of General Science," New York, Teachers' College Contributions to Education, No. 163. The author has included digests of these studies in "A Digest of Investigations in the Teaching of Science in the Elementary and Secondary Schools," Blakiston & Co., Philadelphia, 1926.

Findings

The replies varied from acceptance, with a note of commendation of all the points and sub-points, to one letter, the only one approximating this point of view, which expressed dissatisfaction with the entire outline.

Not all of the authorities evaluated each head and sub-head separately as requested: some marked only the main headings and failed to score the sub-points, while a few others scored only the sub-points, where there were any, leaving the main topics unevaluated. It seems reasonable in such cases, however, to infer that these markers intended the unmarked items to bear the same evaluations as those assigned to the related main or sub-points.

The tentative outline of scientific attitudes, with a summary of the evaluations of each point by the fifty-eight judges follows:

The percentages given in this outline are interpreted thus: The first main point, "Delay in response during which there may be reflection," was accepted without changes as essential by 62.1 per cent of the 58 judges; as desirable but not essential, by 20.7 per cent; and as unnecessary or undesirable, by 1.7 per cent. This first main point was accepted with some modification as essential by 3.4 per cent; but none who marked it desirable (D) modified it. The numbers in parentheses refer to the cases in which either the main headings were marked and the sub-headings were left unmarked, or vice versa; they represent what the "E," "D," and "U" markings would have totaled, assuming that the omitted markings were intended to be the same as those for the marked items. Such an assumption was not made, however, unless the evaluations of all the sub-points under a given main point were uniform. Thus enough of the judges evaluated both sub-points, 1 and 2, under I as essential, while omitting to mark the main point, to raise the E evaluation from 62.1 per cent to 67.2 per cent; and enough of the judges marked I as essential, while omitting to mark 1 and 2 to raise the E evaluations of these sub-points respectively from 62.1 per cent to 65.5 per cent and from 55.2 per cent to 60.3 per cent, etc.

Tentative Outline of the Scientific Attitudes and Summary of the Opinions Regarding the Various Points and Sub-Points in the Outline

I. Delay in response during which there may be reflection

Without change, E 62.1% (67.2%); D 20.7% (20.7%); U 1.7% (1.7%); No evaluation given 12.1% (6.9%)

With change, E 3.4% (3.4%); D 0 (0)

1. Permitting impartial, unbiased consideration of all possible options

Without change, E 62.1% (65.5%); D 15.5% (17.2%); U 6.9% (8.6%); No evaluation given 6.9% (0)

With change, E 6.9% (6.9%); D 1.7% (1.7%)

2. Leading to the evolving of a plan based upon conscious design instead of upon wasteful trial and error, and clearly looking forward to a prediction of the probable outcome or solution

Without change, E 55.2% (60.3%); D 29.3% (31.0); U 3.4% (3.4%); No evaluation given 8.6% (1.7%)

With change, E 1.7% (1.7%); D 1.7% (1.7%)

II. Habit of weighing evidence with respect to its

Without change, E 72.4% (87.9%); D 3.4% (3.4%); U 1.7% (1.7%); No evaluation given 18.9% (5.2%)

With change, E 3.4% (3.4%); D 0 (0)

1. Soundness

Without change, E 82.8% (87.9%); D 5.2% (5.2%); U 3.4% (3.4%); No evaluation given 5.2% (0).

With change, E 3.4% (3.4%); D 0 (0)

2. Adequacy, involving the developed ability both to recognize when the evidence is inadequate and to select the pertinent from the superfluous or extraneous

Without change, E 74.2% (79.3%); D 12.1% (12.1%); U 1.7% (1.7%); No evaluation given 8.6% (3.4%)

With change, E 3.4% (3.4%); D 0 (0)

III. Conviction of universal basic cause and effect relations, rendering untenable

Without change, E 53.4% (55.2%); D 13.8% (15.5%); U 12.1% (13.8%); No evaluation given 17.2% (12.1%)

With change, E 3.4% (3.4%); D 0 (0)

1. Superstitious beliefs in general, as "hunches," "signs" of "good or bad luck," and charms:

Without change, E 43.1% (53.4%); D 17.2% (18.9%); U 18.9% (22.3%); No evaluation given 17.2% (1.7%)

With change, E 1.7% (1.7%); D 1.7% (1.7%)

2. "Unexplained mysteries;"

Without change, E 15.5% (27.6%); D 32.8% (34.5%); U 25.9% (29.3%); No evaluation given 20.7% (3.4%)

With change, E 5.2% (5.2%); D 0 (0)

3. "Beats all" attitude, commonly revealed by

Without change, E 36.2% (46.6%); D 20.7% (22.3%); U 20.7% (24.1%); No evaluation given 22.4% (6.9%)

With change, E 0 (0); D 0 (0)

(*a*) Too ready credulity.

Without change, E 32.8% (50.0%); D 13.8% (20.6%); U 17.2% (24.1%); No evaluation given 36.2% (5.2%).
With change, E 0 (0); D 0 (0)

(*b*) Tendency to magnify the importance of coincidence.

Without change, E 27.5% (44.8%); D 20.7% (27.6%); U 15.5% (22.3%); No evaluation given 36.2% (5.2%)
With change, E 0 (0); D 0 (0)

IV. Respect for another's point of view, an open-mindedness, and willingness to be convinced by evidence.

Without change, E 82.8% (82.8%); D 8.6% (8.6%); U 1.7% (1.7%); No evaluation given 1.7% (1.7%)
With change, E 5.2% (5.2%); D 0 (0)

V. Sensitive curiosity concerning reasons for happenings, coupled with an ideal

Without change, E 60.3% (65.7%); D 18.9% (18.9%); U 1.7% (1.7%); No evaluation given 13.8% (8.6%)
With change, E 5.2% (5.2%); D 0 (0)

1. Of careful and accurate observation;

Without change, E 74.1% (79.3%); D 15.5% (15.5%); U 1.7% (1.7%); No evaluation given 5.2% (0)
With change, E 3.4% (3.4%); D 0 (0)

2. Of patient collecting of data;

Without change, E 63.8% (68.9%); D 22.4% (22.4%); U 5.2% (5.2%); No evaluation given 6.9% (1.7%)
With change, E 0 (0); D 1.7% (1.7%)

3. Of persistence, despite all adverse conditions of whatever sort may arise, in the successful search for real, fundamental explanations.

Without change, E 62.1% (67.2%); D 29.3% (29.3%); U 3.4% (3.4%); No evaluation given 5.2% (0)
With change, E 0 (0); D 0 (0)

All of the various suggestions contained in the returned questionnaires and accompanying letters are given either as quotations or in substance.

NEW POINTS:

"Desire on individual's part for all the facts."

"Imaginative attitude in a constructive sense in addition to critical attitude."

"The Broader View." "...The scientific attitude is incomplete unless it recognizes the fact that it is a part of the broad culture aimed at both by the Humanities and the Social Sciences."

"Constructive controlled imagination which visions relations between facts."

"Distinction between facts and what one thinks about them. This is the fundamental thing. Then—define fact."

"Interested to search to discover evidence."

MISCELLANEOUS SUGGESTIONS:

"...the words, 'there shall be,' in front of each section."

The suggestion that the points be made in the form of questions, as, "What is the problem?" for I; "What is the evidence which bears upon it?" for II, etc.

"Not enough emphasis upon experimental (observational) character of knowledge."

"First impressions usually most accurate."

DEFINITELY SUGGESTED CHANGES OF ORDER:

"Chronologically this (V) should be I."

"V, II, IV, I, III."

III to come first followed by sub-heads of V; then II.

SPECIFIC RECOMMENDATIONS WITH RESPECT TO EACH POINT IN THE OUTLINE:

I. "Activity in seeking data on solution of challenging problems."

To read, "...there may be reflection unless situation has previously brought a satisfactory response."

Too long delay "increases the confusion often."

It should be "only long enough to insure a clear, concise statement."

Marked "D" with the qualification, "This will depend upon the type of mind of the individual: essential to some, desirable to more; unnecessary to a few."

"Habit of delayed response for suitable reflection (varying with the matter in hand)."

1. Four protested against the inclusion of "all."

Substitution of "pertinent" for "possible."

"...more appropriate to the student of rather mature development."

"Waste of time. Questions should be too specific to permit many ramifications."

Substitution of "encouraging" for "permitting."

"To permit adequate consideration of possible options."

2. "Some definite purpose to accomplish, added as major head or emphasized along with the statement given in the outline."
"Only certain types of problem call for this."
"To permit conscious formation of plan of attack."

II. To read, "Habit of weighing evidence, *i. e.*, of checking all conclusions possible, with respect to . . ."
Rearranged thus: "(*a*) Pertinence; (*b*) Soundness; (*c*) Adequacy."
Should be "Passion for knowledge and accurate statement."
". . . more appropriate to the student of rather mature development."

1. Substitution of "practise in" for "habit of."
Soundness "of data, as to purity, and (D) quantity (depending especially upon completeness)."
2. Delete "developed."
Delete "and to select the pertinent," etc., and add it to II-*a*, after "Soundness."
Suggested as a third subdivision, "the ability and the willingness to distinguish between the facts and what one thinks about them."

III. Suggestion that all sub-headings will disappear "as the scientific attitude becomes established."
Delete "universal."
"The beliefs in the inviolability of cause and effect have held up science many times in history. . . Every fundamental discovery in science overturns some fully accepted and—for their phenomena—fully sound causes and effects. But cause and effect, as most apparent to us, is likely to be the hardest thing to overcome in the understanding of new scientific principles that are presented to us."

1. Delete "hunch"; a hunch being "an intuition which is generally based upon incomplete reasoning."
Protest against "hunches" being rendered "untenable;" the sub-conscious working of the mind may have reasoned out this "premonition" or "hunch."
2. Nine protested against "unexplained;" unexplainable was suggested in its place.
3. "Out of place in this serious study."
(*a*) "Scientific attitude would exclude gullibility."
"This hardly belongs here."
(*b*) "Then, too, while the tendency to magnify the importance of 'coincidence' is doubtless a defect

in a would-be scientist's mental attitude, the opposite attitude of not noticing coincidences (by the way, is there any such thing?) is equally disastrous. *E. g.*—the neglect to be impressed by the 'coincidence' that several determinations of the atomic weight of nitrogen from the air gave a higher number than similar determinations made with nitrogen from chemical compounds postponed for over fifty years the discovery of the rare gases of the atmosphere."

IV. To read, "...willingness to be convinced by 'reliable' evidence." Addition of sub-heading "dealing with uncertainty of printed word."

"...idea could be introduced, 'Try it and see.' "

To read, "...point of view if it is based on facts, an open-mindedness..."

Suggestion to omit IV, it being covered by I and II.

V. Suggestion that this whole topic be changed thus: "Habit of clear and logical thinking...based on

1. Careful and accurate observations encouraged by
   (*a*) Sensitive curiosity concerning reasons for happenings.
   (*b*) A mass of carefully collected data.

   Persistence in all this is essential."

   "Essential only for advanced research...not for the average citizen."

   To read, "Encouraged to sensitivity."

   1. "A careful and accurate observation of data collected by others is more economical than 'careful and accurate observation' and 'patient collecting of data,' since there is such a vast amount available in all the sciences."

      "...seems to me most important in secondary schools."

      To read, "Of careful and accurate observations and reading observation and data collected by others."
   2. "Essential for the research worker but in my judgment it is not even desirable to give extensive training to non-specialists in 'patient collection of data.' "

3. Protest, "Why go to extremes?"
   "May be essential for the research worker (specialist)."
   "... 'real, fundamental,' bad philosophy; I suggest, 'adequate.' "

Considering the relatively small number of "U" marks compared with the "E" and "D" evaluations of the various points, it seemed inadvisable to omit any of these points from a final outline of the scientific attitudes; changes from and additions to the original list were made only when the same recommendation was clearly advocated in two or more replies, or when the wording suggested was an obvious improvement on the original, without changing the original idea.

The Scientific Attitudes (Revised Outline)

I. Conviction of universal basic cause and effect relations, rendering untenable
   1. Superstitious beliefs in general, as "signs" of "good or bad luck," and charms;
   2. "Unexplainable mysteries;"
   3. "Beats all" attitude, commonly revealed by
      (*a*) Too ready credulity.
      (*b*) Tendency to magnify the importance of coincidence.

II. Sensitive curiosity concerning reasons for happenings, coupled with ideals
   1. Of careful and accurate observation, or of equally careful and accurate use of pertinent data previously collected by others;
   2. Of patient collecting of data;
   3. Of persistence in the search for adequate explanation.

III. Habit of delayed response, holding views tentatively for suitable reflection varying with the matter in hand,
   1. To permit adequate consideration of possible options;
   2. To permit a conscious plan of attack, clearly looking forward to a prediction of the probable outcome or solution.

IV. Habit of weighing evidence with respect to its
   1. Pertinence;
   2. Soundness;
   3. Adequacy.

V. Respect for another's point of view, an open-mindedness, and willingness to be convinced by evidence.

A STUDY OF THE MATHEMATICS OF COLORIMETRY BY MEANS OF A GENERAL FORMULA*

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A formula of quite general application in colorimetric analytical procedures can be obtained by substituting carefully defined general terms for the numbers used in making the calculation pertaining to some special analysis. The terms needed are:

P, the portion of solution taken for analysis;
S, the weight of standard substance in the known solution;
V', the volume of the unknown solution;
V'', the volume of the known solution;
U, the colorimeter reading for the unknown solution;
K, the colorimeter reading for the known solution;
N, the number used as a factor to express the analytical results on a conventional basis; and
W, the weight of the standard substance in the unknown solution expressed on the conventional basis indicated in the choice of the number N, above.

P, V', and V'' are usually expressed in cubic centimeters, S and W in milligrams, U and K in colorimeter units, and N as an abstract number.

Substituting these terms in a special calculation, such as that for non-protein nitrogen in protein-free blood filtrate with a plunger type colorimeter by the Folin-Wu[1] method, and rearranging them slightly for convenience, we have:

$$KSNV'/UPV'' = W \qquad (1)$$

Such a formula can easily become a nuisance from a pedagogical point of view if students be allowed to use it in calculations before they understand how to deduce it, but it is very useful for the study of general propositions in colorimetry. To illustrate its use:

1. The Value of SNV'/PV'' Is Constant for Any Single Fixed Analytical Procedure

It may be represented by C, meaning the constant or fixed factor needed in the calculations pertaining to a certain analytical procedure, and it may be calculated and tabulated once for all. Then:

$$KC/U = W \qquad (2)$$

The only variable to be used in a calculation pertaining to a fixed analytical procedure then is the value of K/U. This varies with each analysis. It has been suggested[2] that F, meaning the variable factor needed in a colorimetric calculation, be used to represent K/U. In that case:

* Paper read before the Virginia Academy of Science, University, Va., May 7, 1926.

$$FC = W \tag{3}$$

The values for C, when P, S, V', and V'' are taken as directed in Folin's methods for blood analysis, are shown in the following table:

Analysis for	P Cc. of filtrate	S Mgs.	V' Cc.	V'' Cc.	C (SNV''/PV')
Non-protein nitrogen[3]	5	0.3	50	100	30
Non-protein nitrogen[3]	5	0.5	50	100	50
Urea nitrogen[4]	5	0.3	25	100	15
Creatinine[5]	10	0.03	15	30	1.5
Creatinine[5]	10	0.06	15	30	3
Creatinine[5]	10	0.09	15	30	4.5
Creatinine[5]	10	0.12	15	30	6
Creatine and creatinine[5]	5	0.06	25	50	6
Uric acid[7]	5	0.02	25	25	4
Uric acid[7]	3	0.02	25	25	6.66
Uric acid[7]	10	0.02	25	25	2
Sugar[8]	2	0.2	25	25	100
Sugar[8]	2	0.4	25	25	200
Amino-acid nitrogen[9]	5	0.07	25	25	7
Amino-acid nitrogen[9]	10	0.07	25	25	7
Amino-acid nitrogen[9]	5	0.05	15	30	5

When P represents cc. of filtrate as above, N is 1000. If P represents cc. of blood then N is 100. W shows milligrams per hundred cc. of blood. If S is expressed in milligrams, and P is cc. of blood filtrate and 0.948 (the reciprocal of the specific gravity of blood) is used for N, then W equals percentage. This would, of course, change the value of C, but it would be necessary to calculate it but once in each case.

2. When V' and V'' Are Made Equal the Expression V'/V'' Becomes Unity and Disappears from the Formula Giving

$$KSN/UP = W \tag{4}$$

It is not necessary for the analyst to know the exact volumes, V', and V'', if he knows that they are equal. This may sometimes simplify the calibration of the containers for the known and the unknown. In some of Folin's procedures V' equals V'', and in some V'' is twice as great as V'. In all the latter cases it is possible to make V'' actually equal to V' without violating the principles of the methods. If an analyst chooses to do this his calculations are somewhat simplified and some reagents and distilled water are saved. It is probably never necessary to use more than 50 cc. of solution to rinse cups and test the accuracy of the colorimeter, but if one prepares 100 cc. of the known when the unknown is 50 cc. he can make V'' equal V' by simply using 50 cc. only of the 100 cc. in the formula, and using the corresponding value of S also, of course, at the same time.

3. If the Value of K/U Is to Be Calculated for Use as a Separate Factor (F), in Equations 1 to 4, It Is a Decided Advantage to Make U the Divisor and to Choose Such a Value for It as Will Make the Division Short

All values for F when the divisor is 20 and the readings for the dividends are from 10.0 to 45.9, have been published.[2] And every one of them is exact, fifty per cent requiring two decimals only, and the other fifty per cent requiring but three decimals to express them. When K is set on 20 or any other number, most of the readings for U cause long division, and many of the factors have to be rounded off to avoid the use of more than three decimals. When U is set on 10 we have the simplest possible calculations, but the experimental errors are larger than when it is set on 20. It seems easy for manufacturers to make the divisions on colorimeters twice as large with vernier readings twice as close. The favorite point, 20, on the present scale, would then be 10 on the new one thus giving a simpler divisor without sacrificing experimental accuracy.

4. The Expression SNV'/UPV'' May Be Used as a Single Factor by Which to Multiply K to Obtain W

This expression has six variables in it, and it is evident that its value is very easily varied. The possibilities suggest a large field for research, which will not be touched on here. Discussion will be confined to Folin's methods of analysis as they are, and the numerous other possibilities will be passed by. The most desirable factor, evidently, is unity. In such a case the reading for K gives the value of W directly with no calculation whatever. This factor is obtained when the unknown is set on 15 in Folin's procedure for urea nitrogen in blood filtrate, the reading for K being the number of milligrams in 100 cc. of blood. Similarly the reading for K shows the total non-protein nitrogen when the unknown is set on 30. These values are obtained by substituting the values of S, N, V', P, and V'', making the whole expression equal the factor desired, and solving for U. It is not feasible to make the factor unity in all cases. One of the criteria by which the feasibility of making the factor unity is determined is to calculate the value of K/U alone. The nearer this value is to unity the better are the conditions from an experimental point of view. In advising that neither the known nor the unknown should be more than one and a half times the other in volume, except in exceptional cases, Folin[10] fixed the limits of K/U between 0.667 and 1.500.

When the factor cannot be made unity, it is often easy to make it some simple whole number or decimal fraction expressible by a single figure. For example, if the factor desired to use with K in Folin's method for sugar in blood with his weaker standard, is to be 5, U is found to be 20. Therefore when the unknown is set on 20, the value of K multiplied by 5 gives the glucose in 100 cc. of blood. Similarly when the setting is on 20 and the stronger standard is used, the factor is 10. In Folin's procedure

for uric acid with 5 cc. of filtrate and 0.02 mg. as a standard, the factor is 0.2 when the unknown is set on 20. In the method for creatinine in blood filtrate the factors are 0.1, 0.2, 0.3, and 0.4 according to the standards, 0.03, 0.06, 0.09, and 0.12, provided that the unknown is set on 15. If it is set on 30 these factors are one-half the values given. Similarly factors can be obtained for Folin's other procedures, and for numerous others still. It is worthy of note that each factor would be twice as large if colorimeter divisions were twice as large and the unknown were set on numbers just half as great numerically as those mentioned above. The value of W would not be changed.

In conclusion a few words concerning dilution type colorimeters should be appropriate. By inverting the expression K/U in Equations 1, 2, and 4, the formulas

$$USNV'/KPV'' = W \tag{5}$$

$$UC/K = W \tag{6},$$

and

$$USN/KP = W \tag{7}$$

are obtained, which are applicable when the dilution type colorimeter is used. In Equation 3, F may represent U/K as well as K/U making it applicable to problems connected with analyses made with the dilution type colorimeter.[2] The limitations of this kind of colorimeter are appreciable, however, when it comes to simplifying calculations. With a plunger type instrument one of the cups can be set, and the other moved up or down to match them, but with the dilution type instrument filled to a certain mark with a view to making the division short, it is imperative that the unknown be the stronger of the two solutions, and that the process of diluting it be stopped at just the right time. Nevertheless it is possible to use factors in these calculations in much the same way that they may be used with the plunger type instruments, and the dilution type colorimeter is endorsed by high authority for use in some work.[11]

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[3] Folin, Otto, "Laboratory Manual of Biological Chemistry," D. Appleton and Co., New York, **1926,** p. 233.

[4] *Ibid.*, p. 237.

[5] *Ibid.*, p. 243.

[6] *Ibid.*, p. 245.

[7] *Ibid.*, p. 247.

[8] *Ibid.*, p. 263.

[9] *Ibid.*, p. 269.

[10] *Ibid.*, p. 125.

[11] Myers, Victor C., "Practical Chemical Analysis of Blood," C. V. Mosby, St. Louis, **1924,** p. 207.

POTENTIOMETRIC TITRATIONS AS A MEANS OF TEACHING ELECTROCHEMICAL PRINCIPLES

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Introduction

One of the best ways to make the progress of various types of reaction clear to the student is to have him follow a few representative titrations by the potentiometric method. By thoughtful study of these processes it is possible to correlate ideas about electrolytic dissociation, electrode potentials (and many other electrochemical principles), with the theory of indicators, and with the fundamental theory of titration reactions, whether they be neutralizations, precipitation or complex-formation reactions, or oxidation-reduction reactions. This preliminary study will serve as a valuable introduction to more precise measurements of electromotive force that are capable of many-sided theoretical and practical applications.

Single Electrode Potentials

The potential difference between a chemical element (made into an electrode of suitable form), and the solution of its ions, is given by the relation:

$$E = \text{const.} - \frac{RT}{nF} \ln \frac{c_2}{c_1} \text{*}$$

c_1 denotes the concentration of the element in the electrode (substance consumed), and c_2 that of the ions (substance produced). When c_1 is a constant the expression may be written:

$$E = \text{const.}' - \frac{RT}{nF} \ln c$$

c being the concentration (or activity) of the ions of the element. Upon inserting numerical values for R, the gas constant (8.31 Joules), T abs. (298 at 25°C.), F, the faraday (96,500 coulombs), and multiplying by 2.303 to change from natural to Briggsian logarithms, we have:

$$E = E_0 - \frac{0.0591}{n} \log c \text{ (at 25°C.)}$$

where n is the valence change involved. When $c = 1$, the second term on the right of the equation vanishes. The E_0 values are, therefore, the familiar normal potential values for the elements.

The question of sign of electromotive force depends upon whether we consider the tendency of positive electricity to flow from left to right across

* Derived from the van't Hoff reaction isotherm equation. See Taylor's Treatise on Physical Chemistry (D. Van Nostrand Co.) p. 843 for literature references to this and other derivations, *e. g.*, by Nernst, Peters, or Crotogino, respectively. See also W. Blum, THIS JOURNAL, **2**, 557 (1925).

the electrode boundaries within the cell (G. N. Lewis' convention), or whether we consider the tendency with reference to the external circuit. The latter is more convenient for our purposes. The above expression is valid for an element that gives a negative ion, *e. g.*, iodine. If we consider an element that forms positive ions:

$$E = E_0 + \frac{0.0591}{n} \log c \text{ (at 25°C.)}$$

Here E_0 has the sign of the metal, *e. g.*, silver + 0.80 volt, copper + 0.34 volt, zinc −0.76 volt.

Indicator Electrodes

The fact that is important for titrations is that *the potential of the electrode changes* $\frac{0.0591}{n}$ *volt for a ten-fold change in the ion concentration* (or for a ten-fold change in the ratio *oxidized*:*reduced* form, in an oxidation-reduction reaction).

Hence in any titration we should expect the end-point to be marked by a maximum rate of change of electrode potential per drop of reagent added.

A suitable electrode should therefore give a picture of the whole course of the reaction and a sharp indication of the end-point. A silver electrode may be used to follow the course of the precipitation of silver with halide, or vice versa. A hydrogen electrode is used as an indicator of the end-point of a neutralization, or for measurement of hydrogen-ion concentration. A bright piece of platinum will act as an indicator electrode in many oxidation-reduction reactions.

Indirect Indications. It is not always necessary or desirable to use an electrode made of the element whose ions are to be determined. For example, it is sometimes inconvenient or impractical to use a hydrogen electrode as indicator of hydrogen ions. A great variety of oxidation-reduction electrodes vary more or less regularly with change in hydrogen-ion concentration, and thus serve for the determination of end-points, and in some cases for exact hydrogen-ion concentration measurement. The quinhydrone electrode serves for the latter purpose in acid solutions. The reaction at the electrode may be written:

$$\underset{\text{(quinone)}}{C_6H_4O_2} + 2H^+ + \underset{\text{(neg. charges)}}{2\epsilon} \rightleftharpoons \underset{\text{hydroquinone}}{C_6H_4O_2H_2}$$

The electromotive force expression is:

$$E = \text{const.} + \frac{0.0591}{2} \log \frac{[\text{quinone}][H^+]^2}{[\text{hydroquinone}]}$$

The electrode is made up by using quinhydrone, the equimolecular com-

pound of quinone and hydroquinone, hence:

$$[\text{quinone}] = [\text{hydroquinone}]$$

Hence

$$E = \text{const.} + \frac{0.0591}{2} \log [H^+]^2 = E_0 + 0.0591 \log [H^+].$$

Therefore, the quinhydrone electrode varies 0.0591 volt per ten-fold change in $[H^+]$ just as the hydrogen electrode does.

The titration cell is made up of an **indicator electrode** and a constant or **reference electrode.**

Reference Electrode

One of the most convenient reference electrodes is the calomel electrode, or half-cell. Mercury is covered with calomel intimately mixed with mercury particles, and covered with potassium chloride solution of definite concentration. The mercury-ion (ous) concentration is, therefore, invariant at constant temperature. Many other practically constant systems are available, *e. g.*, mercury, mercurous sulfate, sulfate ion; silver, silver chloride, chloride ion solution, etc.

The reference electrode is connected to the titration vessel by a tube containing a concentrated salt solution. There is a difference of potential at the junction of the two liquids that is of the order of a few millivolts. This is ignored in using the cell for titration purposes. In more exact work the liquid potential must be determined, eliminated, or otherwise taken into account.

The electromotive force of the titration cell is measured during the titration by means of a simple potentiometer.

Potentiometer Principle

Some modification of the Poggendorf compensation principle is of most general utility, although other simplified devices may be used in special titrations where conditions are favorable. The simple slide-wire potentiometer represented in Figure 1 will serve for general titration purposes.

The wire AB is of uniform resistance. The fall in potential A to B may be set at some convenient value, *e. g.*, 1.0, or 1.5 volts, by means of a standard of electromotive force (standard cell) that can be put in place of the titration cell X. When the titration cell is in circuit the contact C is moved until the galvanometer shows no deflection when the key, K, is tapped. The distance AC then measures the e. m. f. of the titration cell:

$$\frac{\text{e. m. f. of titr. cell}}{\text{e. m. f. } A \text{ to } B} = \frac{AC}{AB}.$$

The writer has found the somewhat more elaborate apparatus shown in Figure 2 to be very convenient.

Potentiometric Titrations

All classes of reactions that occur in aqueous solutions have been followed by the potentiometric method. A few simple illustrations will serve to indicate the scope of the method.

Precipitation Reactions. Much study has been devoted to the determination of the halides with silver nitrate, or vice versa, using a silver indicator electrode. A potassium nitrate salt bridge is interposed between the calomel electrode and the titration beaker. It is possible to determine the individual halides with great accuracy. Iodide may be determined

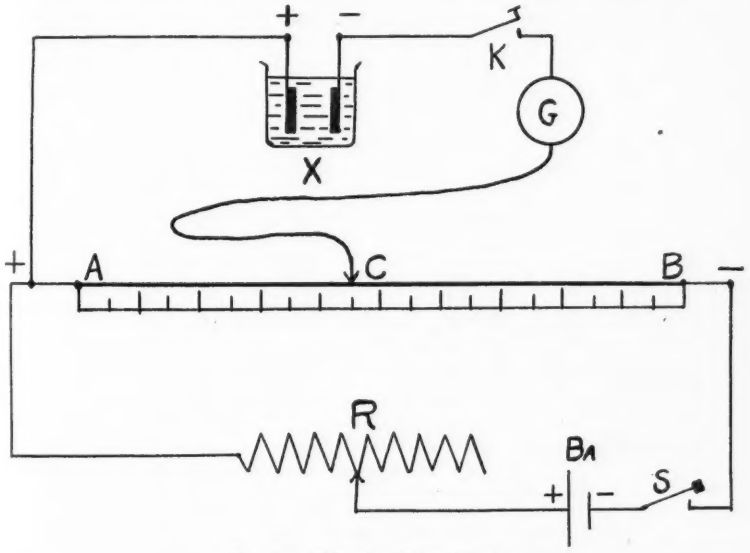

FIG. 1.—Slide-wire Potentiometer.

Ba, ordinary dry cell; *S*, switch; *R*, resistance; *AB*, slide-wire; *C*, sliding contact; *X*, titration cell; *K*, tapping key; *G*, galvanometer.

accurately in the presence of chloride or bromide. The solution should be stirred vigorously (motor stirrer) and the silver nitrate added slowly. The presence of barium nitrate or alum tends to prevent chloride or bromide from being precipitated with the silver iodide. The curves in Figure 3 show the course of the reaction. The dotted curve shows the much sharper drop in the e. m. f. of the titration cell that is found when iodide alone is present. If the value of the *N* calomel electrode is taken as 0.283 volt at 25°C. referred to the *N* hydrogen electrode as 0.0000 volt, and if the liquid junction potentials between *N* KCl and the KNO_3 bridge, and

between the latter and the solution, are ignored, the e. m. f. at the end-point may be calculated:

Assuming that the solubility product of AgI is 10^{-16}, the concentration of $[Ag^+]$ at the end-point is $\sqrt{10^{-16}} = 10^{-8}$.

Hence

$$E_{\text{Calomel}} - E_{\text{Silver}} = 0.283 - (0.80 + 0.0591 \log 10^{-8})$$
$$= 0.283 - 0.327 = -0.044 \text{ volt.}$$

It can be seen from the experimentally determined curve that the actual end-point is reasonably close to the calculated value.

The change at the end-point obviously depends upon the solubility of the salt (which determines the concentration of the metal ion), upon the

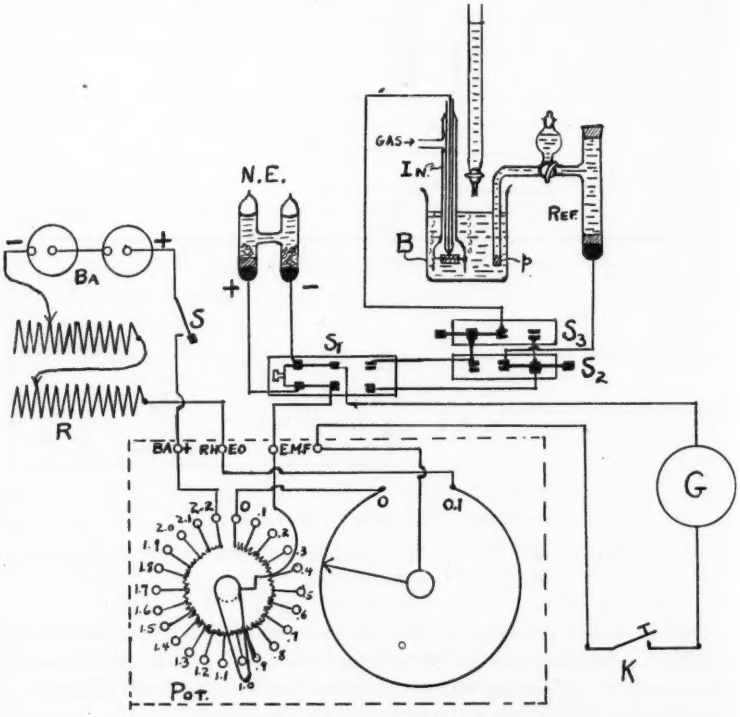

FIG. 2.—A Convenient Titration Outfit

Ba, battery; *R*, resistance (1000); *S*, battery switch; *Pot.*, potentiometer (Leeds and Northrup Students' type); *N. E.*, Weston standard cell; S_1, double-throw reversing switch; *G*, galvanometer; *K*, tapping key; S_2, S_3, single pole double-throw switches; *B*, titration cell; *In.*, indicator electrode; *Ref.*, reference electrode (*N* calomel cell); *p*, plug or capillary to prevent diffusion.

volume of the solution, and the concentration of the titrating reagent. Suppose 25 cc. of 0.1 N $AgNO_3$ have been added to 25 cc. 0.1 N KI. What change is to be expected upon adding 1 drop (0.05 cc.) of reagent in excess? 0.05 cc. per 50 cc. corresponds to 1 cc. 0.1 N solution per liter, or a silver-ion concentration of 10^{-4} N. Hence the first drop of reagent beyond the equivalence point causes 4 units of change in the exponent of $[Ag^+]$, corresponding to 4×0.0591 volt in the e. m. f.

The solubility product principle may also be applied to the calculation

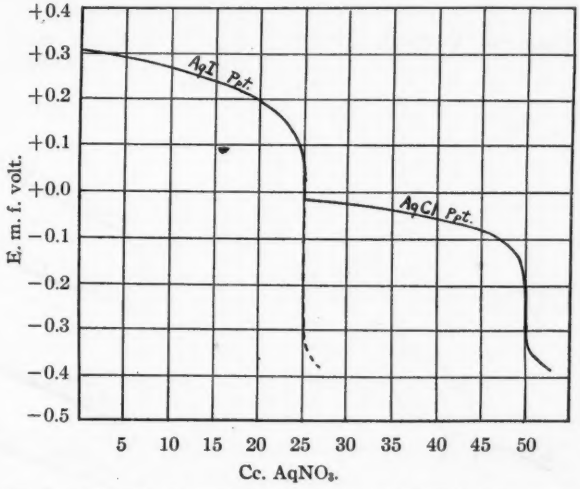

FIG. 3.—Titration of Mixture of Chloride and Iodide with Silver Nitrate

25 cc. approx. 0.1 N KI and 25 cc. approx. 0.1 N KCl titrated with equivalent silver nitrate. The dotted portion shows the course of the curve when iodide alone is titrated with silver nitrate.

of the change in e. m. f. during the course of the precipitation of iodide and chloride in a mixture. The course of the curve (Fig. 3) is very closely reproduced in this way.

From the simple relation:

$$\frac{[I^-]}{[Cl^-]} = \frac{S.P._{AgI}}{S.P._{AgCl}} = \frac{10^{-16}}{10^{-8}} = \frac{1}{1{,}000{,}000}$$

we should expect that an accurate determination of iodide could be made in the presence of chloride. If this expression were strictly valid the concentration of unprecipitated iodide would be negligible at the start of the precipitation of silver chloride.

If the ions that form the precipitate are of different valence the relations are more complex, but it is still possible to calculate the course of the reaction.

Complex-Formation Reactions. Without entering into details, it will suffice to state that the formation of stable complex ions may be followed by the potentiometric method. The addition of cyanide to silver solution causes precipitation of silver argenticyanide, $Ag[Ag(CN)_2]$, which dissolves to form the stable complex ion $Ag(CN)_2^-$. There is one break,

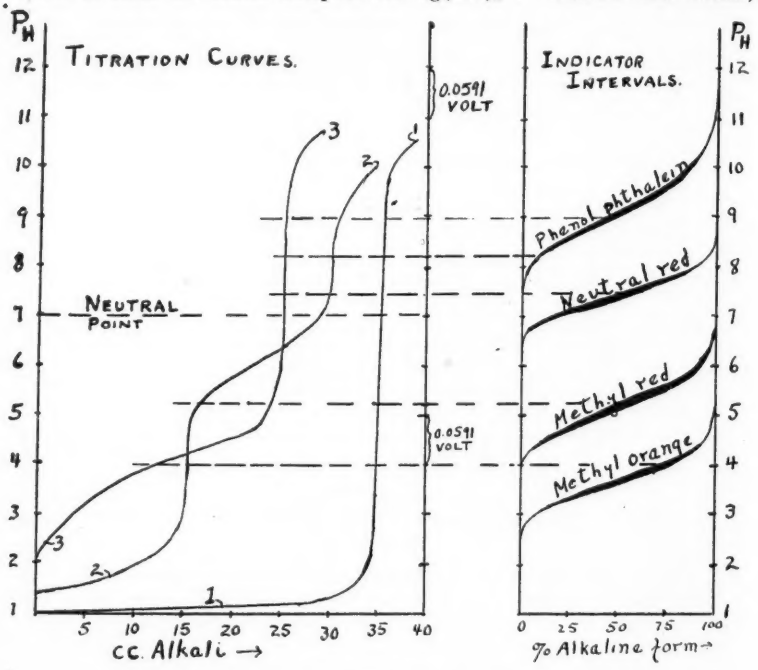

FIG. 4.—Titration Curves and Indicator Changes.

Curve 1. Approx. 0.1 *N* sulfuric acid titrated with NaOH of equivalent strength. Curve 2. 40 cc. 0.0711 *N* phosphoric acid titrated with 0.2 *N* NaOH (data of Davis, Oakes, and Salisbury, *Ind. Eng. Chem.*, **15**, 182 (1923)). Curve 3. 25 cc. 0.5 *N* acetic acid titrated with 0.5 *N* NaOH. The dotted lines carried across from the right of the figure represent the mid-points of the most clearly visible changes (approximately).

or jump, in potential at the end of the precipitation process, and a second at the completion of the complex-ion formation. The reverse process, titration of cyanide with silver, has found application in the determination of halide in the presence of cyanide.

Neutralizations. The outstanding example of combination of ions to

form a slightly dissociated compound is to be found in neutralizations. Other reactions of this type, *e. g.*, formation of certain slightly dissociated organic acids, etc., may also be followed by the potentiometric method. The indicator electrode for neutralizations is usually a hydrogen electrode of the form shown in Figure 2. When the hydrogen electrode is inapplicable, indirect methods may be applied (cf. section on Indirect Indications).

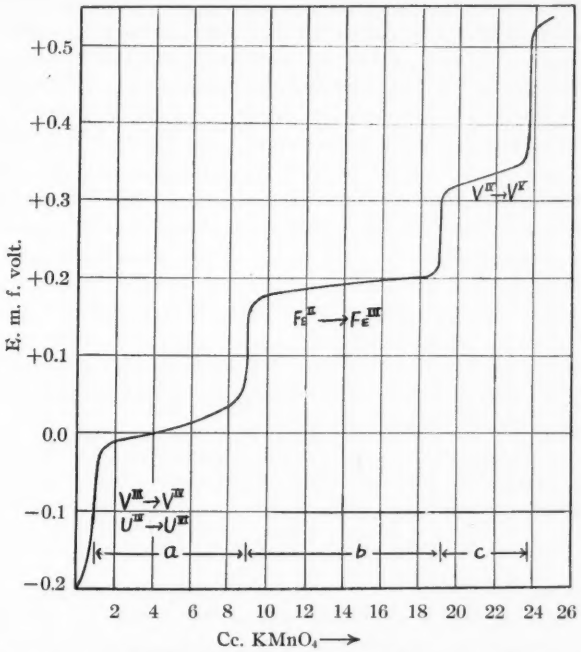

FIG. 5.—Simultaneous Determination of Uranium, Iron, and Vanadium by Titration with Permanganate.

Data of Müller and Flath, *Z. Elektrochem.*, **29**, 500 (1923). The number of cc. permanganate given by $a - c$ corresponds to oxidation of uranium; b cc. are equivalent to the iron, and c cc. to the vanadium present.

The fundamental assumption that is used in calculating the course of the various reactions is that at constant temperature the ion product of water, $[H^+] \times [OH^-]$ is a constant, of value very closely 10^{-14} at room temperature.

It is very instructive for the student to follow the course of the neutralizations of equivalent portions of two acids of widely different "strengths." The nature and magnitude of the difference is very clearly revealed.

The information obtained by the potentiometric method may be readily correlated with the transition ranges of indicators (Fig. 4).

More exact measurements of hydrogen-ion concentration by the potentiometric method find numerous important applications that cannot be enumerated here (cf. W. M. Clark).

Oxidation-Reduction Reactions. The potentiometric method is of especial value in determining the end-points of oxidation-reduction reactions because relatively few oxidation-reduction indicators are available (*e. g.*, diphenylamine reactions, methylene blue reactions, etc.). In some cases the reagent acts as its own indicator (permanganate). In others external indicators (spot-plate methods) give accurate results, although the process is somewhat tedious. The potentiometric method, on the other hand, serves as an almost universal oxidation-reduction indicator (platinum indicator electrode and calomel reference electrode). It possesses the added advantage that several oxidizing, or reducing, agents can be determined by one titration (cf. Fig. 5). It is not possible to calculate the course of the titration curve with as much confidence in oxidation-reduction reactions as in the case of precipitations or neutralizations. Irreversible electrode effects are generally found. The e. m. f. is also very largely influenced by the hydrogen-ion concentration in the majority of these reactions. There are, therefore, several variable factors to consider, even when the electrode process is regular.

In the ideal case of a simple reaction, *e. g.*, $Fe^{++} \rightleftarrows Fe^{+++} + \epsilon$, that is but little affected by acid concentration (in dilute solution) we should expect the expression:

$$E = E_0 + \frac{0.0591}{1} \log \frac{[Fe^{+++}]}{[Fe^{++}]}$$

to represent the changes in e. m. f., or in this case a change of 0.0591 volt per ten-fold change in the ratio of $[Fe^{++}]$ to $[Fe^{+++}]$. When ferrous iron is oxidized it is found that there is a maximum in the rate of change of the e. m. f. at the equivalence point.

If an univalent ion is oxidized with a polyvalent ion the titration curve is not symmetrical on opposite sides of the equivalence point and the mid-point of the region of sharp change does not coincide with the maximum rate of change in the e. m. f. In such instances it is better in principle to take the maximum rate of change as the end-point.

In this brief article it has not been possible to mention the investigators who have developed this interesting field of work. Some of the text-books that are mentioned in the brief bibliography give a complete survey of the literature. It was thought worthwhile to single out a few of the earlier investigations that may be regarded as sources for study of the development of potentiometric titration methods.

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Hildebrand, J. H., "The Use of the Hydrogen Electrode in Analysis, Teaching, and Research," *J. Am. Chem. Soc.*, **35**, 869 (1913).

The technic of the potentiometric method, and the extensive literature of the subject are given in the following texts:

Clark, W. M., "The Determination of Hydrogen Ions," 2nd ed., Williams and Wilkins Co., Baltimore, Md.

Furman, N. Howell, "Chapter XIII of Taylor's Treatise on Physical Chemistry," D. Van Nostrand & Co., New York, 1924.

Kolthoff, I. M., and Furman, N. Howell, "Potentiometric Titrations, A Theoretical and Practical Treatise," 350 pp., John Wiley & Sons, Inc., New York, 1926.

Müller, E., "Elektrometrische Massanalyse," Theodor Steinkopf, Dresden, 3rd ed.

Iodine, Favorite Antiseptic, Now Has Rival in Neglected Chemical. Iodine, for many years a favorite first-aid antiseptic for bruises and cuts, is now having its preeminence challenged by potassium permanganate, a compound long known to scientists but hitherto little used by people in general. Its advocates point out certain advantages it has over iodine, which they claim will eventually cause it to replace the older drug.

In the first place, they state, it is not poisonous as iodine is and, therefore, not so dangerous to inquisitive children. Furthermore, it does not smart and burn when applied and an overdose will not cause harm to the flesh. It is also pointed out that in the dry state potassium permanganate keeps indefinitely, whereas iodine deteriorates in time.

For ordinary treatment half a teaspoonful of potassium permanganate crystals in a cup of water is sufficient, but for ivy poisoning a teaspoonful to a cup is recommended. For very severe poisoning, such as snake bite, the dry crystals are pressed directly into the wound, or into small knife incisions about it.—*Science Service*

Radio Hits Shellac Industry. With the radio replacing the phonograph in almost every home the shellac shipments from India into this country are only half what they used to be two years ago. At least half of the shellac used in the United States, which is one of the biggest importers of this necessary constituent of varnish, formerly went into the manufacture of phonograph records, according to a report to the American Chemical Society.

In consequence the shellac producers of India, or rather the human powers who have control of the sticky gum deposited on the twigs of trees by the lac insects, have become panicky. They likewise remember the decline and fall of the indigo industry when synthetic indigo was finally produced in the laboratory. Anxious to forestall a similar fate for natural shellac they have attempted to safeguard themselves by getting in on the ground floor of the synthetic stuff in establishing a Lac Research Institute which has as an additional aim the improvement of the quality and output of their product.—*Science Service*

A SIMPLE SPINTHARISCOPE

L. C. CARTWRIGHT, UNIVERSITY OF FLORIDA, GAINESVILLE, FLORIDA

It is much easier than one might imagine for the average person, without expensive apparatus, to observe a striking demonstration of radio-activity. All the apparatus that is necessary is a low-power microscope or a simple convex lens with a focal length of two or three centimeters, and a bit of luminous paint of the radio-active type such as is found on luminous watches. It is also necessary to have access to a dark-room, or else to make one's observations at night.

If one will hold a luminous watch very close to the eye in the dark and look straight at the glowing figures with the eye wide open and the luminous paint about a centimeter from the eye, one will see that there is not a steady glow, but a flickering light such as comes from a dying fire. To get this effect it is necessary that the observer and the watch shall have been in the dark for some time. The observer's eyes must become thoroughly rested and the watch must remain in the dark long enough for the glow due to phosphorescence to fade, leaving only the faint flickering glow due to the radio-active radiations.

Crystals of phosphorescent zinc sulfide are rendered luminous when exposed to fairly intense radiation from a radio-active substance. This phenomenon is due to the bombardment of the crystals of zinc sulfide by the alpha-rays, which are helium nuclei discharged by the radio-active atoms in the process of disintegration. The impact of each alpha particle upon the zinc sulfide produces a separate flash, but the flashes are so minute and so numerous that they ordinarily appear as a continuous glow. However, under certain conditions, one may observe the individual flashes.

The luminous paint on watches usually consists of phosphorescent zinc sulfide with which is mixed a trace of radio-active matter. Only an exceedingly minute quantity of radio-active matter is needed to give a life of several years to such luminous paints. A radio-active material with a comparatively short life is used, because it yields more intense radiation, but, due to difficulties of purification and to disintegration, there are always several elements of the radio-active series present.

Perhaps the reader is wondering what to do with the lens. Having observed the faint flickering glow, one should examine the luminous paint with the lens. When it is correctly focused, the luminous figures appear to be glowing and flashing like an electric sign. One may even distinguish separate flashes brighter than the others in the scintillating mass. This really becomes a magnificent spectacle, after one has remained in the dark for a long time.

If a microscope is to be used, the lowest power objective should be focused on the paint and the microscope placed in the dark. The eyes must be even more thoroughly rested in this case. Some care is required in the

dark to line the eye up with the barrel of the microscope, but one soon becomes accustomed to it. The glow appears fainter with the microscope, and the whole scene is slightly blurred, but the separate flashes are more readily distinguished.

If one wishes to obtain the very best results, one may prepare slides of the paint. Secure two small glass plates such as microscope slide glasses. Cut a piece of white paper the size of the glass plates, and write an appropriate label on it. With a knife, carefully scrape a bit of luminous paint off an old watch. The paint should be finely powdered, and spread very sparingly over the white paper. Leave a little pile of paint dust the size of a pin head near the center of the paper. Now place the paper between the two glass plates, hold them tightly together and seal them around the edges with gum shellac. This may be done by melting little droplets of the shellac onto the edges of the glass, and then smoothing it down with a very hot knife. With a little practice one can make a neat, permanent, water-proof slide, labeled and convenient to use. Such a slide is much better to demonstrate the effects of radio-activity than the luminous paint as found on the watch, because the slide gives a less intense radiation and the individual flashes are very readily distinguished.

The writer has prepared a number of these slides and they have been used to advantage by classes studying the structure of the atom. It is suggested that this method of demonstrating radio-activity might be of particular value to teachers of chemistry and physics in high schools where more expensive apparatus is not available.

Cosmic Rays to Be Examined in Heights of Andes. The mysterious cosmic ray is due for another checking-up, this time in the heights of the Andes mountains. Dr. R. A. Millikan, world-famed investigator of the new radiation, and Dr. G. Harvey Cameron, his associate in this field, expect to make a scientific excursion during September to one of the highest lakes of Bolivia. Present indications show the best prospects in or near the Quimsacruz mountain range, a few miles southeast of La Paz. Peaks of 15,000 to 22,000 feet altitude, and numerous lakes abound here.

The experiments with the new high-frequency penetrant radiation require the use of a deep alpine lake, free from radio-active salts, and at a very great altitude. It is possible in Bolivia to drive vehicles to altitudes higher than any lake in the United States. With this situation, Dr. Millikan hopes to be able to conduct experiments at some location nearly a mile higher than the scene of last summer's epochal discoveries. Heavy apparatus will have to be transported. Despite the great altitude it is anticipated that the tropical warm season will afford the best chance to avoid frozen lakes.

By attaining the altitude of three miles or more from sea level, the Pasadena physicists expect to eliminate most of the dimming effect of the atmosphere on the cosmic rays. It is then possible by means of a delicate quartz-hair electroscope to receive and identify the remarkable energy emanations. Only by immersing the apparatus deep in a lake is it possible to obtain a blank control test, which is compared with the reception of radiation in the open.—*Science Service*

Correspondence

STIMULATING JUVENILE INTEREST IN SCIENCE

TO THE EDITOR:

There is one phase in the teaching of chemistry that seems to be neglected exceedingly in spite of its vital importance.

I have noted with interest that somebody touched on the subject in an article entitled, "Why Are Students Not More Interested in Chemistry?" in which the author points out the fact that the subject of chemistry in high schools and institutions of higher learning is generally regarded as a rather dry, difficult, and uninteresting subject and especially so with the gentler sex. Might not the explanation for this be that they have not been gradually led into it but have suddenly been pushed over the precipice into deep water? The average student has a very meager appreciation and knowledge of things scientific when he commences a course. Contrast this to history in which the child has been steeped in the lore of heroes ever since he was first capable of understanding. Why cannot science and especially chemistry be made a place for adventure, struggle, discovery, and victory in the stories for our youth as well as other things.

As H. G. Wells says in his novel, "The World Set Free," in regard to this generation as looked back upon by the future: "It is wonderful how our ancestors bore themselves toward science. They hated it, they feared it. They permitted a few scientific men to work and exist. 'Spare our little ways from the fearful shaft of understanding,' they said, 'do tricks for us, give us cheap lighting, cure our cancer, consumption, and colds.' "

There is a measure of truth in this statement that cannot be overlooked. Such men as Wells and Slosson are doing an excellent work for the grown-ups and we need more of them but most of all we need this type of thing for the child and the adolescent so that when the time arrives, they may come to the class-room with an appreciation and an interest already developed instead of entering upon something that is strange and new and naturally—uninteresting.

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BRUCE H. GUILD

SIGMA ZETA

TO THE EDITOR:

Many readers of the JOURNAL OF CHEMICAL EDUCATION, I believe, will

be interested in the recent founding of the Sigma Zeta honorary science society at Shurtleff College, Alton, Ill.

Sigma Zeta was founded with the purpose of giving recognition for high scholarship in science to worthy students in the smaller colleges. So far as the writer has been able to ascertain, there are many small colleges that are unable to secure chapters of Sigma Xi, the well-known scientific society, election to which signalizes scholastic ability in scientific studies. Because Sigma Xi is limited largely to the university field, the small college which does not have a chapter of that organization is unable to recognize, except in a very local fashion, unusual scholarship in its science students. It was to fill this need of the small college that Sigma Zeta was founded October 1, 1925.

In its organization Sigma Zeta is similar to Sigma Xi, each society providing for two classes of membership, associate and active. Associate membership is limited to freshman and sophomore students; active membership is designed for only the two upper classes. Both young men and young women students are eligible for membership provided they are able to meet the high scholastic requirements necessary for election.

At the regular meetings, which have been held fortnightly during 1925–1926, members have presented papers upon subjects of general interest to science. Occasionally an outside speaker has contributed an informal talk upon research in some one of the various industries represented in the Alton industrial district.

Just before the end of the college year a charter and articles of incorporation were received by Sigma Zeta from the secretary of the state of Illinois, empowering the society to recognize scientific scholarship and to grant chapters in other institutions. McKendree College of Lebanon, Ill., at once petitioned for the installation of what will be known as the Beta chapter. The extension of the society to other small colleges in the state and, ultimately, in other sections of the country is a future development hoped for by the founders, who believe that in the college with about 500 students Sigma Zeta may be a powerful aid in stimulating undergraduate interest in scientific studies.

Correspondence regarding Sigma Zeta may be addressed to the Grand Secretary, Professor E. E. List, Shurtleff College, Alton, Ill.

SHURTLEFF COLLEGE,
ALTON, ILL.

R. K. CARLETON

The pursuit of science strengthens the intelligence without weakening the energy, without blunting the sensitiveness, without chilling any of the good qualities, the germ of which has been placed in the human heart by nature.—FRANCOIS ARAGO

Chemical Digest

VENABLE HALL*

The fiftieth anniversary of the rehabilitation of this ancient seat of learning after the Civil War and the dedication of a modern, palatial home for the cultivation of chemistry—a science ever close to man, his constant companion in the advancement of civilization—are events of rich import.

Chemistry is the noblest of sciences. It is not a "fountain shut up.... a book sealed...." It is very human. Consider how medicine leans upon it. It has developed preventative medicine and is daily adding to its dominant place in medicine by its many fresh and wholesome discoveries.

And thus it has ever been, embracing the whole range of created nature; comprehending in its researches all substances, animate and inanimate; exploring their elementary principles; unfolding their combinations; tracing their affinities and ascertaining their new combinations. In every employment its influence is felt and its aid desired.

Dear old Peter Shaw, M.D., two hundred years ago, published three "Essays in Artificial Philosophy or Universal Chemistry" in which he set forth the virtues of the science in "the commercial arts," such as "the making of hard oil soaps; producing vinegars; curing fish and flesh; condensing commodities for exportation; and packing commercial products with an account of certain *chemical contrivances*, capable of deceiving travellers and merchants in the condition of the commodities; with the most expeditious ways of detecting such impositions, as the sophistication of Wines, Brandies, Vinegars, and Arracs; the Debasement of Gold Sand, Gold Bars or Ingots, Silver, Copper, and Tin, counterfeit gems, etc., etc." And then he expatiated on a "Chemical History of Culinary Arts," saying interesting things about "the best Fewel for Kitchen Use"; suggesting a method for rendering it cheap and inoffensive, and casually referring to "the Art of Edulcorating the refuse Fat of a *Kitchen*, for Lamps, or other economical Uses," and also introducing "the best Methods of preserving all the metalline furniture of a Kitchen from *Rust* and *Tarnish*," outlining at the same time procedures for expressing salad oils from various seeds, especially mustard, and describing "the preparation of the *finest* salt for the table."

A wonderful book was that of Peter Shaw, M.D., from which you have received a few extracts. It was a veritable domestic science epitome,

* Abstract of an address delivered by Dr. Edgar F. Smith on the occasion of the dedication of Venable Hall of Chemistry at the University of North Carolina, October 12, 1925.

plainly indicating chemistry to be the "human science," coming home to every man's business and bosom—"descending with humble industry to the assistance of the manufacturer at his loom, or the dyer over his vat." The book is a message from far gone days, but is still modern in its purposes.

In old Yale there was in by-past times an eminent president, yes, I recall that he was fifth executive head of the University. He was a very learned man—a very intimate friend of that wise, astute savant and diplomat Franklin, with whom he was in constant correspondence. Ezra Stiles, in some mysterious way, had been touched by the erroneous spirit of alchemy; that of making gold and silver from worthless, discarded substances. He emphatically denied the allegation that he was a transmuter. Perhaps he was compelled to do this in order to protect himself from the inquiries of his Trustees who, in those days as in the present, would spy out the land. He was singularly successful and left volumes of notes, when he passed on, which he little dreamed would be most illuminating to those to whom chemistry appealed. For the most part they were written in Latin and tell of nightly hours devoted to the performance of all manner of experiments in search of the long-sought substance which would effect the marvelous transformations ardently sought and prayed for by alchemists. Note that it was in the night that Stiles pursued his occult studies and, as I read his records, I found myself in imagination working with him and often visualized him sitting at an open window, hands folded, in his little home, gazing out into the darkest night and hearing these apostrophized words, "O Night! black nurse of the *golden* stars!" The aim of the alchemists was *gold*—ever in their minds and before their poor wearied souls! This narrative is but a side issue. It may be laid away to be revived at hearthstone gatherings on long winter evenings when thoughts naturally revert to the days and occurrences of the dim past.

"When did your science begin here in America?" you ask. Well, if I must tell of the "Rock from whence we were hewed and the hole of the pit from whence we were digged," I would say that it began long, long before the days of the sainted Ezra Stiles.

It was in Old Virginia, in the year 1608, that, through the necessity of self-preservation and with the obsession that the motherland should receive evidences of the material worth of her new possessions, the pioneers strove with astounding obstacles through the long days and still longer nights "beneath that arch of unmoved and eternal lights" to plant there, on Southern soil, a glass house, a mile from Jamestown, standing in the woods, very unpretentious in its dimensions and appointments yet it was the first manufactory ever erected in this country. In it were made glass plate and attractive colored glass beads, the current coin with the Indians. Chemistry was the dominant science in all this.

A salt works was set up at Cape Charles on the Eastern Shore and iron

works at Falling Creek in Jamestown River, where proof of good iron was carried out, and so near perfection was the whole works brought that "they (the pioneers) writ word to the Company in London that they did not doubt but to finish the work, and have a plentiful provision of iron for them by the next Easter." Lead ore was discovered and worked. Silk was cultivated from the mulberry tree. Indeed "it is said that Charles II wore at his coronation in 1661, a robe and hose of Virginia silk." Those acquainted with the applications of chemistry were occupied with these undertakings. And then the end came. The hitherto amicable Indians put into execution a general massacre. The iron works and the glass house were ruthlessly demolished, and the manufacture of all other commodities was abandoned. It was a sad period, crushing the hopes of those sturdy pioneers. The streets of Jamestown and all its surrounding neighborhood were given over to the cultivation of tobacco. To Massachusetts went the spirit of chemistry, there to develop new industries and drown out forever the alchemical ideas which had even entered Boston Harbor.

I wish also to bring to your attention a fact touching all Carolinians. Quite early the indigo plant had been found indigenous to the soil. Indeed, as early as 1719, Miss Eliza Lucas, the mother of Charles Colesworth Pinckney, was, at the age of eighteen years, in charge of a plantation in South Carolina where she sowed the indigo seed. Success crowned her efforts so that in the course of a few years indigo began to be exported. In 1741, about 100,000 pounds of indigo were sent to England from Charleston. In 1743, wearing apparel was abundantly dyed with indigo. In Revolutionary days it was the sole color used everywhere with home-made material. Think for a moment that in this beautiful Southland a color, which for years grew in plant form in India and was in a sense the cause of the devastating famines of that land, until chemists gave to the world an artificial product, was grown, extracted by original methods, and used at home and abroad, and regarded as one of "the most profitable articles of French colonial commerce."

From the Carolinas went the experience of indigo manufacture, fostered so enthusiastically, into Georgia there to contribute to its people some of the welfare enjoyed by Carolinians, and, were one to search diligently, the same industry would be uncovered in Mississippi and in Louisiana. Chemistry in its subtle ramifications may be observed in the earliest days of all the colonies bordering the Atlantic. The narration of its story would fill many stout volumes in the study of which there would be borne in upon us that there was a "chemistry in America" of vast importance and interest.

Let me say that chemists all over the land are happy in the knowledge that this splendid structure devoted to their science has come to the University of North Carolina, which, through its many able teachers and in-

vestigators, has added much to the science and will contribute, in the future, even greater results, for those in command are equipped and long for the opportunity which is now theirs. Personally, I am very happy that the name attached to this structure is that of my friend, Francis P. Venable, whose achievements are most favorably known far and wide and who from long association I have found to be "One of those golden Natures who help us form our ideals of life."

FRANCIS PRESTON VENABLE*

The father of Dr. Venable, who was professor of mathematics at the University of Virginia, no doubt hoped that he would take up a career in mathematics, but it was not so foreordained. For some considerable period the choice, *mirabile dictu*, lay between Greek and chemistry. The decision was reached after he had been admitted to assist Dr. J. W. Mallet in his famous research on the atomic weight of aluminum. It is noteworthy that the present accepted atomic weight of aluminum comes from this investigation. Dr. Mallet was careful in the selection of his assistants and frequently allowed a period of probation to elapse before admitting a candidate to all the rights and privileges of an assistantship. In the present case the probationary task was the preparation of numerous gallons of distilled water, the drops of which should never come from the condenser faster than could be counted. After a week or more of drop counting the candidate was found to have passed a preliminary examination. It is not surprising that Dr. Venable has required of his students utmost care and a scrupulous search for the facts, with all the possible confirmatory tests.

FRANCIS P. VENABLE†

After a period of study in Germany under several of the masters, Dr. Venable returned to the United States to accept a call as professor of chemistry in the University of North Carolina, just a few years after its re-

* Abstract of article under above title by James M. Bell, *Ind. Eng. Chem.*, **16**, 755 (1924).

† Cut by courtesy of *Industrial and Engineering Chemistry*.

opening following reconstruction days. In spite of the inadequacy of equipment and of the overload of teaching, Dr. Venable, already known as "Old Ven," on account of an awe-inspiring beard, with the coöperation of the late Dr. Joseph A. Holmes, then professor of geology, and other kindred spirits, organized the Elisha Mitchell Scientific Society. At the recently celebrated fortieth anniversary the history of the society was read by its first president, Dr. Venable. The foundation of this society may be truly said to mark the beginning of the research spirit in the South.

It is a marvel that with this heavy load of teaching and class preparation there was any time left for investigation. Yet at nearly every monthly meeting of the Mitchell Society the results of some work in chemistry were reported by professor or students. One of the early volumes of the *Journal of the Elisha Mitchell Scientific Society* has a description of a modification of the Bunsen burner designed by Dr. Venable, a modification still in general use, although it goes by another name. After twenty years of service in the department of chemistry he was elected president of the university, and for fourteen years he served in that capacity. During this administration, one new building was added to the campus group each year, often under adverse circumstances. To his constant insistence on sound scholarship and high academic standards may be attributed the high regard in which the university now stands. In 1914 his health required that he relinquish the increasingly onerous duties of president, and he returned to his beloved chemistry.

An historical sketch of Dr. Venable would have recounted his numerous honors—several honorary doctor's degrees, secretary and vice president of the American Association for the Advancement of Science, and president of the American Chemical Society, and a long list of contributions to the literature, mainly in inorganic chemistry. This sketch is a failure if the reader has not gained the conviction that here we have a sound scholar, an inspiring teacher, a careful experimenter, a wise counselor, and withal a delightful companion and true friend. W. R. W.

THE REVOLT AGAINST EDUCATION*

During the last hundred years, according to Dr. Frank, the same thing has been happening to our education that has been happening to our civilization as a whole. It is suffering from structural overloading and is finding it difficult to carry with ease and efficiency the increasing burden it has itself been creating. Sir Francis Galton puts his theory in these

* Glenn Frank, "The Revolt against Education," *Nation*, **122**, 574–6 (1926); *Sch. and Soc.*, **23**, 729–41 (1926).

words, "Our race is overweighted. It will degenerate under circumstances which make demands that excel its powers." He concludes, "Our civilization is more complex than our statesmen are capable of dealing with. There is crying need for greater ability than men possess." Dr. Frank writes:

I suggest that the enormous increase of knowledge and the increasing complexity of the curriculum in our universities is analogous to the increase of things and the increasing complexity of social organization in our civilization as a whole. It is, perhaps, more than analogous. It may well be an organic part of the larger social process that Galton suggested. We are witnessing today both the collapse of our curricula from structural overloading and the beginnings of a student revolt against the sterilities of current academic procedure.

A hundred or more years ago the outlines of a college education were simple. In the centuries immediately preceding, knowledge had not increased at a pace so rapid but that educators could digest, interpret, and relate to previous knowledge the new knowledge as it appeared. But—if I may generalize rather roughly—with the nineteenth century the invigorating winds of a new critical and scientific spirit began to blow across the world. The scientific spirit began hunting, blasting, boring, probing, boiling, cooking, and dissecting. Men animated by the itch to know began to throw up, at a disconcerting rate, all sorts of new facts and new knowledge. These facts and this new knowledge were, of course, thrown on the study tables of the educators. Before long it became apparent that the new knowledge was coming faster than it could be digested and fitted intelligently into any educational scheme.

It was thus that the elective system was brought into existence. Educators, feeling helpless in the face of a mass of new knowledge they could not readily assimilate, made a strategic retreat from a definitely planned curriculum to an extreme elective system.

Confronted with new facts and new knowledge, growing at a speed that outstripped the possibility of prompt correlation at the time, the educational world adopted as its fundamental method of *handling* knowledge the method that was *producing* knowledge, namely, specialization. It is measurably accurate, I think, to say that the principle of specialization today dominates and directs almost entirely both curriculum content and teaching method. Few will dispute that the primacy of the principle is 90 per cent inevitable. This 90 per cent inevitability need not, however, blind us to some of the bad by-products of specialization. And I suspect that it is in devising ways and means for preventing these bad by-products of specialization that the next fruitful advances in educational policy and procedure are most likely to be made.

In speaking of the unhappy results of specialization as they affect scientists and teachers, Dr. Frank says:

It is the common uncritical assumption of the layman that while extreme specialization in education is the undoubted foe of broad culture it is the unquestioned friend of science. But it is obvious, I think, that the relatively unrestricted application of the principle of specialization to education may result in our producing, generation after generation, scientists of narrower and narrower intellectual equipment, until a time may come when we shall be producing scientific workers too narrow either to conceive or to comprehend those brave flights of imagination, those far-visioned generalizations, those

creative hypotheses which have heretofore preceded and played a decisive part in producing every really epochal scientific advance. We may find it necessary to protect the specialists against specialization so that they may be better specialists.

There is always involved in an education that is dominated by the principle of specialization the temptation to permit specialization to become the master instead of the servant of the scholar. The teacher who succumbs to this temptation finds himself becoming more and more a slave to subject-matter, and finds his teaching effectiveness, as provoker and guide in the learning process, correspondingly diminished. And he is likely to end as a counterfeit educator who looks upon the educational process as the science of putting something into the student mind rather than as the art of starting something in the student mind.

Dr. Frank suggests that:

We might undertake to prevent the abuse and to promote the ultimate utility of specialization by making an effort to insure, as far as possible, that students shall at least be exposed to a broadly conceived and coherently organized body of general knowledge during some definite period of the college years that precede the intensive specialization of graduate study and professional training. . . . . Such a new organization of subject-matter could be made possible only by the courageous willingness of educators to be tentatively dogmatic in saying what subject-matter will best induct the student into an understanding of his contemporary world, of the forces that have gone into its making from the past and of the living forces that are most likely to determine its future. Specialization has converted our universities into intellectual department stores, or, more accurately, into a series of intellectual specialty shops housed under a common administrative roof. And any attempt to effect a new synthesis of knowledge even in an important section of the college years encounters as a stubborn obstacle the otherwise healthy hesitancy of the scholar to generalize. But no such fresh organization of subject-matter as I have suggested would be possible save at the hands of educators who refused to be awed by the mere bulk of modern knowledge, educators who were willing to undertake a frankly tentative but nevertheless definite synthesis of the major findings of modern knowledge. . . . . .

If we find ourselves driven frankly to admit that knowledge is growing more rapidly than educators can fetter it and synthesize it in any curriculum, may it not be necessary for us to strive to develop educational processes in the undergraduate years that will deal more directly with the mental processes of the student than do many of our present methods of teaching and examination that lay so much emphasis on subject-matter? May it not be that the only way in which the modern man can hope to keep pace with the modern world is to increase the tempo of his mind as the tempo of the advance of knowledge increases? . . . . . .

I suggest that the attempt to make education concern itself more directly with the development of the speed and accuracy of the student's mind will force us to reckon with this platitudinous and harmless-sounding but, I suspect, revolutionary proposition, namely, that we make the teaching process take its cue from the learning process instead of compelling the learning process to follow the technic of teaching as in the main we do today. . . .

It may be that we shall find it impossible, as a practical teaching problem, ever to overcome the dangerous separateness of the fields of modern knowledge and to give students a sense of synthesis through a reorganized curriculum. Inevitable specialization may have outstripped the possibility of any such synthesis in terms of a curriculum. If that proves our conclusion, may it be that we shall be driven to depend upon a few departments in our colleges to help students maintain a sense of the relatedness of things?

May it be that we shall have to ask, say, the departments of philosophy, literature, and history to accept special responsibility for helping students to see knowledge steadily and to see it whole? If so, what readjustments would that mean in the subject-matter and technic of these departments? Might it not mean that these departments would become the points at which the specialists would meet in something approaching a venture in coöperative teaching? W. R. W.

ABSTRACTS OF PAPERS TO BE DELIVERED AT THE PHILADELPHIA MEETING OF THE A. C. S.*

A Secondary School Course in Industrial Chemistry

R. E. BOWMAN

The vocational objective of secondary education has had scant consideration from high-school and college teachers who have been concerned mainly with college entrance and its attendant problems. Chemistry is given too late to reach two-thirds of the laboratory workers of non-college grade. A vocational school can train such workers and prepare many who will become future analysts, operators, and foremen for the chemical industries, especially in communities having large chemical plants. A course is being worked out at Wilmington Trade School from a job analysis of the actual work of laboratorians in the local plants.

Atomic Structure Charts

HAROLD J. BARRETT

Description of a project for the presentation of atomic structure to beginners. Exhibition of charts prepared by students which explain periodicity by means of the Lewis-Langmuir octet theory.

A Carbohydrate Relationship Chart

HAROLD J. BARRETT AND CLYDE W. EDDY

An aid to the visualization of the relationships among the pentoses and hexoses.

A Presentation of Osmotic Pressure

HAROLD J. BARRETT

A common-sense illustration which gives beginners a better understanding of osmotic pressure and its measurement.

* Partial list only.

The Planning of a Chemical Laboratory. No. II

J. N. SWAN

In making the floor plans for a chemical laboratory it is worthwhile to plan so that each part of the building will best serve its purpose and not interfere with the work of other parts of the building. With the stock-room the first consideration, its availability to everybody, in the case of a private laboratory there may be the opposite requirement. Obnoxious rooms should be located where they bring a minimum of disturbance, corridors are not just ornamental. All rooms must be located after considering the conditions involved in the use of these rooms.

What are these requirements and how do the various shapes of floor plans lend themselves to satisfy all of the considerations involved?

Standards in College Degree Courses in Chemistry and Chemical Engineering from the Quantitative Viewpoint

LOUIS W. MATTERN

An analysis and comparison of the requirements in science and chemistry between the college degrees in chemistry and in chemical engineering.

This will be based on a section of the statistics bearing on standards in chemical education obtained from 80 publicly controlled and 103 privately controlled universities and colleges throughout the United States.

This section of statistics, which will form the basis of some timely conclusions, will be summarized on lantern slides in such a way as to give a bird's eye view of the practice in the above institutions which grant college degrees in chemistry and in chemical engineering.

A New Method of Laboratory Instruction

HERBERT R. SMITH

Extra time for the laboratory of science is the generally accepted plan of instruction at present. The average teacher of chemistry is not making efficient use of this time by reason of the methods employed. The pupils, steeped in conning other lessons from books, naturally use the same method with the study of chemistry, particularly when lessons are assigned from a text-book. Little individual thinking is required when the laboratory practice "follows the text."

The laboratory time should be used to gather facts and to draw from them their significance which will determine lines of future action. This practice should be suitably introduced but not by the too prevailing plan of telling the pupil most of the results before he begins. Time used in collecting data is justified only when definite use is made of it to develop reasoning, or to serve some practical purpose in life. The knowledge should be developed from its natural life setting and should make unmistakable contact with the different phases of modern life. The manner of presentation should imbue the pupil with the "worthwhile" quality of the subject. Carefully worded questions are the best means of promoting pupil thinking. A definite marking off of fundamentals is required to secure their thorough mastery.

The function of a text-book is to serve as a means of amplifying and extending the study of an assigned topic that has been initiated in the laboratory.

(An exhibit contrasting the old with the new method accompanies the presentation of this paper.)

Coöperation between the Eastern New York Section of the American Chemical Society and the High Schools

WHEELER P. DAVEY AND THOMAS A. WILSON

This section sends out certain chosen members to address the science classes of such high schools as care to hear them. These lecturers emphasize:

(1) All the material portion of our modern civilization is founded directly on science.

(2) No modern American can claim to be educated without at least an elementary knowledge of the fundamental sciences.

(3) Therefore, these sciences are the most important subjects taught in our schools.

These speakers have fulfilled seventeen speaking engagements during the past school year, including one meeting with a business men's organization.

Photography as a Recording Medium and Its Application in the Publication of Scientific Papers

G. E. MATTHEWS AND J. I. CRABTREE

The objects of the paper are to acquaint scientific workers with the value of photography as a medium for recording chemical and physical

reactions and to show the application of photographic illustrations in the publication of scientific information. The majority of scientists do not make use of photography to any extent. The simplicity of photographic methods is outlined with a view to assisting the research worker in making his own photographic records. These may take the form of purely illustrative results or they may be an analytical means of recording data. Records prepared in either of these ways will usually serve as valuable assets for instructional and educational work.

The characteristics of the photographic emulsion are described in order to acquaint the scientific investigator with the limitations of this medium for recording data. Several examples are given illustrating the varied uses in chemistry, physics, and other sciences to which the photographic emulsion has already been adapted. These examples show the value of photographs in clarifying and condensing data for scientific papers. Practical recommendations are made on the choice of methods and the most suitable sensitive materials for recording purposes.

A Survey of Visual Chemical Instruction

FELIX A. ELLIOTT

Brief historical survey of the various visual methods such as printing, epidiascopes, lantern slides, photographic prints, and motion pictures.

A discussion of the fundamental fitness of each method giving its limitations and its advantages. Most of this discussion is based on scientifically observed comparisons of methods.

In conclusion an attempt will be made to show how the activity of chemical educators will have to be directed in order to make available material of each type and how to do so as soon as possible.

Computations in General Chemistry

C. A. BRAUTLECHT

After considerable experimentation with classes in general chemistry, the following procedure has been arrived at: Instead of memorizing procedure formulas, the qualitative and quantitative features of the factors involved in problems are learned by the student. Beginning with temperature scale conversions and gas volume changes the student works problems entirely on a systematic reasoning basis and then deduces the formula. He uses procedure formulas very rarely, however. In

solving problems involving reactions, the student learns to handle problems always in four steps: A, equation; B, statement of equivalence; C, statement of simple proportion involving numerical and qualitative factors; D, solution of simple proportion on the basis of the fact that the product of the extremes equals the product of the means. When handled in this way, it has been found that problems have been less of a drag. This procedure also offers the best opportunity of cancellation of numerical and qualitative factors, the use of logarithms and slide rules. It is, moreover, more subject to accurate inspection by the student, and, above all, yields correct results with almost every student. Students working on the basis of memorized formulas, where these are not used repeatedly, make frequent errors. Reaction problems worked on the basis of only the equation and then the statement, 7x equals 733, for illustration, too frequently obtain incorrect results, spend much time in arriving at a result, and confuse qualitative factors badly. They overlook facts such as g./cc. equals density, pounds, l., cu. ft., k., as well as whether the substance is hydrogen or sodium hydroxide, etc.

The Technical Terminology of High-School Chemistry Text-Books

S. R. POWERS

A list of the technical terminology has been compiled which comprises all the words occurring in two widely used text-books of high-school chemistry. All terminology which is not included in Thorndike's "List of 10,000 Commonest Words," has been listed together with its frequency. This list is almost wholly technical. The tabulation shows that there were nearly 2000 such words and it shows that some of these were used with considerable frequency, but that nearly forty per cent were used at such low frequency as to suggest that, to these authors, they represent words of little significance. The total "Science Vocabulary" from text-books used in each of the grade levels of the four-year high school consists of nearly 8000 words. The study suggests the means by which vocabulary difficulty of high-school text-books may be reduced.

Devotion to science is a tacit worship—a tacit recognition of worth in the things studied; and by implication in their cause. It is not a mere lip-homage, but a homage expressed in actions—not a mere professed respect, but a respect proved by the sacrifice of time, thought, and labor.—HERBERT SPENCER

ABSTRACTS

Chemistry in 1876. HENRY LEFFMANN. *Catalyst*, **11**, 1–4 (1926).—This article gives us some idea of the state of chemistry at the time of the formation of the American Chemical Society fifty years ago and of the advances made since that time.

By 1876, a large part of the fundamental facts and principles of chemistry had been ascertained and generally accepted. The atom was regarded as an indivisible, indestructible mass; each element was considered essentially distinct in its nature. A fairly comprehensive and favorably regarded text-book which might be taken as a picture of what chemists believed and taught in 1876 is Fowne's "Manual of Chemistry" revised by Henry Watts, F.R.S. In describing this book the author says: "Sixty-four elements are enumerated, didymium being one. Radio-activity is conspicuous by its absence as is also the argon group. Much of the apparatus is of the general type used today, but the spirit lamp, argand burner, and a special form of blast lamp using alcohol are fully described. It is interesting to note the beginning of the use of gas by the expression 'In London and other large towns in which gas is to be had, it is constantly used.' The Bunsen burner is described and figured as a comparatively new apparatus. Considerable space is devoted to the problem of mine explosions, in course of which the Davy lamp is described in some detail. At that time chemists were not aware of the fact that finely divided combustible matter is capable of causing most violent explosions."

The advances of chemistry in the last fifty years are enumerated as follows:

Great development of physical chemistry, so much so that it now seems about to swallow up chemistry proper. The most impressive evidence of this is the enormous literature on colloid chemistry.

The discovery of radio-active elements and their degradation products with the concomitant demonstrations of interconvertibility of elements.

The elucidation of the structure of the atom and of the arrangements of the atoms in solid substances.

The development of the classification by atomic weights resulting in the establishment of the series known as the atomic numbers, with its fertile suggestions of new elements.

The extension of chemistry into industry on the one hand and into biology on the other. Incident to this two specific developments have come: the manufacture of analyzed chemicals and the introduction of standard methods of analysis.

W. R. W.

Some New Organic Germanium Compounds. L. S. FOSTER. *New England Assoc. Chem. Teachers*, **27**, 123 (1926).—Although discovered in 1886, germanium is still quite rare and quite costly. In 1907 germanium oxide was quoted at $5000 a gram and last year Kohlbaum quoted it at $130 per gram, but it is now available at $8 a gram. Germanium resembles tin and silicon, and precipitates as a white sulfide in the H_2S group. Due to its high cost, no practical use has been developed and the element has been but slightly studied. In accordance with Mendelejeff's predictions it forms organic compounds. Most of those prepared are aromatic although some aliphatic compounds have been made. In this article the preparation of several new aromatic compounds is described in which zinc is introduced to form zinc diphenyl previous to the introduction of germanium tetra-bromide, instead of using the ordinary Grignard reaction which gives a low yield.

D. C. L.

Contributions of American Chemists to Industrial Progress. J. H. NAIR. *Syracuse Chemist*, May, **1926.**—The discovery of element No. 61 by Professor B. S. Hopkins has stimulated interest in the accomplishments of American chemists; in this short article are given a few of their achievements. The discovery of the cracking process, the development of a cheap method of producing aluminum, the discovery of the vulcanizing process, the building of a dye industry in this country, the researches into the commercial production of helium, the development of synthetic resins, advancements in photography, and the production of pyrex and anti-knock compounds are mentioned as the chief commercial contributions of the chemist. In the field of medicine, insulin and adrenaline are the most recent discoveries.

D. C. L.

Electrolytic Iron from Ilmenite Ores. R. H. MONK AND R. J. TRAILL. *Can. Chem. & Met.*, **10**, 137 (1926).—The practical utilization of titanium-iron ores has long baffled investigators, but with the development of cheap electric power a solution of the difficulties is offered. The ore containing about 31% TiO_2 and 40% Fe is crushed and heated with coal or coke at a temperature of 950°C. for $1\frac{1}{2}$ hours, forming iron sponge. The product is crushed and the metallic iron removed from the gangue with a

magnetic separator. This iron sponge contains about 47% Fe, 37% TiO_2, and 2% C. The sponge is leached with ferric chloride solution which dissolves the iron, forming ferrous chloride, while the TiO_2 remains unaffected. After the removal of the small amounts of Cu, Pb, Ni and Co present with CaS, the iron is plated out on a revolving cathode.

Due to its high purity new uses are being found for electrolytic iron. Its ductility after initial annealing, the ease with which it can be cold-rolled and used for stamping, its electrical properties, high purity, and slow corrosion are constantly opening new fields.

The titanium concentrates are used in the manufacture of white pigments, glassware, and chemicals. The chief handicap of titanium oxide as a pigment has been its high cost, but with a reduction in cost it will probably compete with ZnO and lithopone.

D. C. L.

Technic for Teaching of Physics and Chemistry. EUSTACE BLOOM. *High-School Teacher*, **2**, 224–7 (1926).—The routine text-lecture-laboratory method of teaching physics and chemistry is said to be wasteful both of student's time and school funds. The writer finds a better substitute for this wasteful method by using a combination of the Dalton-Winetka-project plans.

The assignments are made upon mimeograph sheets in terms of units which are larger than usual daily assignments. Each sheet contains what are called three block contracts. The first of these is for students desiring a grade of F (passing to average). The minimum grade permitted on this is F. The second contract for students desiring a grade of G (average through good) requires the reading of an additional text-book reference and additional problem and experimental work. Minimum grade, that this additional work may be accepted, is G. The third contract provides work for students desiring a rating of E (excellent). This makes provision for additional problem and laboratory work but requires a grade of E upon work in contract 2.

This plan provides for the exercise of individual initiative by the student. It provides a method of recognizing individual differences and of keeping all profitably employed at their particular level of ability.

In general the plan seeks to place the responsibility more definitely upon the student for planning and carrying forward his work. Tabulations show something of the accomplishments of a small group studying physics. Conclusions are summarized under nine heads.

B. C. H.

Isolation or Coöperation in Research. VERNON KELLOGG. *Bull. Am. Assoc. Univ. Profs.*, **12**, 341–2 (1926).—The idea is that a group of men shall be brought together "to undertake investigation in conformity with a coördinated plan. This involves the statement of a major problem needing solution, its analysis into specific parts and an organized distribution, by mutual agreement, of these parts to individual workers or small groups of workers whose work, when accomplished, shall all be brought together and made known for the general benefit that this contribution to scientific knowledge may effect." This kind of organization still seems to excite criticism. This opposition seems to grow out of the idea that great advances in science have been made in the past by individuals.

History seems to show that these individuals made use of results to which many men had made separate contributions. These men who made the epoch-making discoveries were unusual men. They were geniuses. There are so few such men that it is necessary for those who are not geniuses to coöperate that something worthwhile may be achieved.

B. C. H.

Teaching as a Profession. HENRY SUZZELLO. *Bull. Am. Assoc. Univ. Profs.*, **12**, 330–5 (1926).—The big problem confronting this profession is the danger of losing its autonomy. Politics seek to dominate it; economy pleas leading to centralization of power in government have a tendency to drag in the schools; certain groups are seeking to make the schools a medium for carrying forward special propagandistic campaigns and there is a tendency to seek to legislate modifications of curricula. To get autonomy for the practice of the profession two obligations are called for: we must not offend the public's sense of fair play and we as a group must live up to our assumption of expertness in educational affairs. "To the extent we make our educational profession a scientific organization will society leave us alone, give us autonomy and permit us to perform our duties without undue lay interference?"

B. C. H.

The Social Message of the Modern Church. W. R. INGE. *Bull. Am. Assoc. Univ. Profs.*, **12**, 337–8 (1926).—The author says "I believe that in science has come the chief revelation of the will and purposes of God that has been made to our generation. I believe that it is more important for the Christian preacher to understand this new revelation, and to apply it to his ethical teaching, than to cultivate a sympathy with

social revolution and the 'demands' of manual labor.—Perhaps the great struggle of the future will be between science and sentimentalism and it is by no means certain that the right side will win.—In so far as we connect the Kingdom of God with the progress of the human race, we who are Christian ministers ought to give more attention than we have hitherto done to the discoveries of modern science and the scientific way of looking at things." B. C. H.

Report on the Examination of Sprayed Apples for Arsenic. F. T. SHUTT. *Can. Chem. & Met.* **10,** 130 (1926).—Following the report of arsenical poisoning in England from eating imported sprayed apples, an investigation of the arsenic content of sprayed apples was made by the Canadian government. Forty-three samples of different varieties from four provinces were analyzed. Most samples had been subjected to four or more sprayings. Results show that half the samples were entirely free from arsenic, one-sixth contained less than $^1/_{10,000}$ grains per pound, and one-third between $^1/_{10,000}$ and $^1/_{100}$ of a grain per pound.

"With the heaviest amount of arsenic found it would require three pounds or one dozen apples of average size to supply the minimum medical dose of arsenic, and four dozen to supply the maximum medical dose." D. C. L.

Chemistry and Human Progress. *Radio Publication*, No. **21,** University of Pittsburgh.—This is a series of seven short radio talks given by various members of the faculty, and constitutes the second series of talks given by members of the faculty. The topics in their order of presentation are: (1) Chemistry Extending the Borderline of Civilization, which covers a few of the most important scientific advances of the last two centuries, (2) Maintaining a Safe Milk Supply, (3) From Atmosphere to Soil, (4) Dyes as a Civilizing Factor, (5) Explosives and Human Progress, (6) Speeding Up That Process by Catalysis, (7) Where Will Chemistry Lead Us?

The subjects are presented in an interesting and popular manner and a select bibliography is given at the end of each talk. D. C. L.

The Sources of Spencer's Education. H. G. GOOD. *J. Educ. Res.*, **13,** 325–35 (1926).—In Spencer's book on "Education," the fundamental ideas for three of his essays were taken from Rousseau, Fellenberg, Bacon, Richter, Combe, and Pestalozzi, the views in most cases being credited to their authors; the style and illustrations being essentially Spencer's. The main argument of the introductory chapter, "What Knowledge Is of Most Worth?" has always been credited to Spencer. Investigation by the author, however, shows that this chapter is an expansion of the ideas of Joseph Priestley contained in his educational writings, *viz.*—Essay on a Course of Liberal Education for Civil and Active Life; Remarks on a Proposed Code of Education; Miscellaneous Observations Relating to Education. Six pages of parallel passages are quoted in which it is shown that priority for most of the ideas contained in Spencer's introductory essay must be given to Priestley. R. M. P.

Training Research Workers. C. C. CRAWFORD. *J. Educ. Res.*, **13,** 636–70 (1926).—University authorities assume that students who by temperament should become investigators will force their way into the field of research. Many who would do this are discouraged by the apparently superhuman tasks now required of research students. A university course in training for research work would relieve this situation. Large scale methods of training in research may be used equally as well as the large-scale production of standardized automobiles. Training for research may be reduced to fundamental principles and types, thus, in part, doing away with the apprentice system now in vogue, which often has a narrowing influence, and which wastes the time of professor and of student. The author suggests a program of formal training in methods of research, each prospective graduate student to have the privilege of taking it regardless of the field in which he plans to do his graduate work. This program is not intended to replace individual work but rather to serve as a foundation for it. R. M. P.

Comparative Effectiveness of the Lecture Demonstration and Individual Laboratory Method. FRED G. ANIBEL. *J. Educ. Res.*, **13,** 355–65 (1926).—This article describes an experiment from the chemistry department of Central High School, Kansas City, in which the same material was given to balanced groups of students, to one group by lecture demonstration and to the other by individual laboratory method. Interpretation of the tabulated results gives the conclusions: (1) Immediate retention is fully as adequate by lecture-demonstration method. (2) There was a slight indication that material was better remembered by individual laboratory procedure. (3) Brighter students are likely to profit more by lecture-demonstration method. (4) Lecture demonstration requires about two-thirds as much time for presenting experiments. (5) Cost of lecture demonstration is much less, being about one-fifteenth as great as for the individual laboratory method. R. M. P.

Local Activities and Opportunities

University of Nebraska. The following individuals have been added to the staff of the department of chemistry for the coming year. Dr. E. R. Washburn from the University of Michigan as an instructor and Mr. S. A. Durban from the University of Texas as a fellow.

Dr. C. M. Knudson who has been instructor in the department of chemistry for the past two years has accepted a position with the Continental Oil Company at their plant at Tulsa, Oklahoma.

The Arts College of the University of Nebraska is considering the feasibility of offering a two-years' generalized course in science for its freshmen and sophomores. The matter is in the hands of the science departments' chairmen who are expected to report back to the faculty in the early fall.

Carnegie Institute of Technology. Thirteen graduates of colleges and universities have been appointed Research Fellows to conduct an unusually extensive program of studies in mining and metallurgy during the coming year. The work, as in the past, will be carried on by the Department of Mining and Metallurgical Engineering, in coöperation with the Pittsburgh Station of the U. S. Bureau of Mines and under the direction of two advisory boards of engineers and business men representing the mining and metallurgical industries.

Of the thirteen investigators, five will study problems in metallurgy and eight have been assigned to carry on research in problems relating to coal mine engineering. The program of metallurgical studies will be supervised officially by an advisory board of Pittsburgh District Steel men and engineers. The coal mining investigations will be made under similar conditions with an advisory board of coal operators and mining engineers.

Four of the studies will be financed by the Carnegie Institute of Technology, while the remainder of the work will be underwritten by the industries. Among the contributors are the American Gas Association which is interested directly in a study of "warning agents for manufactured gas," The National Coal Assoiation, the New York Edison Company, and other industrial enterprises.

University of Florida. Dr. F. H. Heath, professor of chemistry, U. of Florida, and Dr. L. J. Lewis, professor of chemistry at the Florida State College for Women are two of the eight joint authors of a new "General Chemistry," published July 18th by the Miner Publishing Company. The text is written for use in colleges and universities and contains 650 pages and 122 cuts.

"A Laboratory Manual of General Chemistry" by Professors W. H. Beisler and F. H. Heath, of this department, will be off the press about August 15th. It has been used in mimeographed form in the department for the past two years and is now being published to accompany the text-book announced above.

The "Problem-Question Book" used in this department for the past two years in mimeographed form will also be published to accompany the text-book under the title of a "Quiz Book." Professors Beisler and Heath are the authors. All three of these books are being published by the Miner Publishing Company.

Brown University. The Graduate Department of Brown University has awarded for the year 1926–27 the following fellowships and scholarships in chemistry:

Fellows

Harry H. Reynolds, A.M., Brown 1925, Jesse Metcalf Fellow

Earl H. Brown, A.M., Brown 1926, Jesse Metcalf Fellow
John A. Ridderhof, A.M., Clark University 1924, du Pont Fellow
Howard S. Nutting, M.S., Worcester Polytechnic Institute 1926, Herbert W. Rice Fellow
Arthur M. Neal, A.M., Clark University 1924, University Fellow
Rex W. Kennedy, A.M., Brown 1926, University Fellow
Charles B. Wooster, A.M., Clark University 1925, University Fellow
Cecil L. Brown, A.M., University of Missouri 1922, University Fellow
Wade B. Robinson, B.S., Hobart College 1926, University Fellow
Ernest R. Kline, B.S., Kalamazoo College 1926, University Fellow

University Scholars

Mario Canaipi, B.S., Brown 1926
Walter Katznelson, B.S., Brown 1925
Philip A. Smith, B.S., Brown 1926
Harry Eatough, B.S., Brown 1926
Russell H. Lyon, B.S., Kalamazoo College 1926
Kenneth H. Wildern, B.S., Olivet College 1926
Willard M. Allen, B.S., Hobart College 1926
Ellis F. Parmenter, B.S., Colby College 1926
W. Harlow Kahler, B.S., Olivet College 1926
William W. Hawes, B.S., Purdue 1924

Mr. E. Seaton Carney and Mr. E. Alison Flood have been appointed graduate assistants for 1926–27.

Mr. Laurence S. Foster and Mr. Stanley W. Glass received the degree of Doctor of Philosophy in June. Mr. Glass has accepted a position with the National Carbon Company, Cleveland, Ohio, and Mr. Foster has been added to the chemistry staff at the University of Utah.

Dr. Norris W. Rakestraw, who has been teaching at Oberlin College, Ohio, has been appointed assistant professor in chemistry. He is filling the position left vacant by the death of Professor Herbert F. Davison.

Egbert K. Bacon who received his Ph.D. from the University of Michigan in June has been appointed instructor in chemistry.

Dr. Francis L. Simons, instructor in chemistry, has resigned to accept a position with the firm of Sherman, Skinner, and Esselen, Research Chemists of Boston.

Scientists Are Well Wishers of Poland's Chemist President. The scientific world is watching with interest the newly elected chemist-president of Poland, Prof. Ignatz Moscicki.

Prof. Moscicki has a difficult post attended by many complexities for which the exact habits of scientific thought should qualify him to cut through the tangle of international diplomacy with precision and logical clarity, according to editorial comment in *Industrial and Engineering Chemistry*. He maintains, "I have the habit, as a scientist, to demand exact figures before I make a decision, and if I am unable to do so on the moment I will confess it and tell the truth." An honest statement truly, which no professional diplomat would have the nerve to make.

Much of Prof. Moscicki's former work has been in the field of electrochemistry, carried out while professor of chemical engineering at the University of Freiberg in Switzerland. After Poland was reëstablished as a nation he resigned and became professor at the University of Lemberg, or Lwow as it is now called, to aid in the general development of Polish universities. He has been prominent in developing methods along such practical lines as nitrogen fixation, oil demulsification, and aluminum manufacture and holds more than fifty patents in the chemical field.—*Science Service*

Recent Books

Principles of General Chemistry. STUART R. BRINKLEY. The Macmillan Co., New York, 1926. x + 477 pp. 14 × 21.5 cm. $3.50.

The author states in his preface that "this text is the outgrowth of several years' study of the problems involved in presenting the subject to those students who have had a preparatory-school course in chemistry." Instead of following the usual custom of treating the subject-matter from the standpoint of the different elements, the author has followed a quite different idea by classifying all substances according to the kind of reactions which they exhibit. For example, all of the more important acidic and basic oxides are discussed in Chapters II and III, similarly the different acids and bases are brought together under general headings and salts are classified as halides, sulfates, nitrates, etc. This arrangement not only gives the student a new viewpoint of the subject but should serve to awaken his interest rather than to dull it as is so often the case.

Both the structure of the atom and the periodic law are discussed in Chapter I, thus giving the student at the outset an idea of the unity of matter and a reason for the principles and laws that follow. Little practical use, however, is made of the periodic law later in the book. It is interesting to note that such subjects as hydrogen, valence, and the metals are not treated as major topics but are brought in as incidental to certain principles. The book is well illustrated, is written in an interesting manner and from a standpoint that clearly presupposes some general knowledge of the fundamentals of chemistry. In the opinion of the reviewer it marks a distinct advance over the time-honored method of handling the subject-matter of general chemistry. While the book is well suited for a unified course in general chemistry its arrangement would not permit an easy correlation with qualitative analysis as is the custom in many universities.

GEO. W. SEARS

Indicators. I. M. KOLTHOFF. Translated from the second German edition, revised and enlarged by N. H. Furman. John Wiley & Sons, Inc., New York City, 1926. xii + 269 pp. 23 × 14.5 cm. $3.50.

Drs. Kolthoff and Furman have done a considerable service in so ably collecting, arranging, and discussing our knowledge of neutralization indicators. The book should be of great value to those interested in the theory of the subject as well as to the practical worker. Furman's additions will be much appreciated by those interested in amphoteric compounds and the phenomena exhibited by them. Furthermore the utility of the original German edition has been considerably enhanced by their inclusion.

As would be expected, the theoretical side of the question precedes the practical. The chapter titles give only a faint idea of the real scope of the book. They are Neutralizations, Amphoteric Compounds, The Color Change of Indicators, The Use of Indicators in Quantitative Neutralizations, The Colorimetric Determination of Hydrogen-Ion Concentration, Practical Applications of the Colorimetric Determination of Hydrogen-Ion Concentration, Indicator Papers, Theory of Indicators. Included in these chapters we find tables of the Sörensen, Clark and Lubs, Cohen, and Michaelis and Gyemant indicators covering name, trade name, concentration, p_H interval and color changes. Following this each indicator is discussed in detail. Here we find the structural formula, directions for use, and a statement of the salt error and general utility. Occasionally methods of purification are given. There is an extensive discussion of salt and protein errors, and of the effect of heat, concentration, and alcohol on sensitivity. The tables of buffer mixtures are very complete and the discussion of the same excellent.

One wonders why the chapter on Theory of Indicators was not placed together with the chapter on The Color Change of Indicators. Especially puzzling, however, is the omission of any discussion, or even mention, of the indicator cochineal. Of course this is not a very sensitive or reproducible indicator, but it is so often specified and used as an indicator in ammonia titrations, that the inclusion of some discussion on it would seem to be advisable. At least a suitable substitute should be recommended.

It is very gratifying to find an exceedingly full bibliography at the end of each chapter. There is also an extensive table on the dissociation constants of acids and bases with full literature reference. A diagrammatic p_H-% conversion chart for 23 indicators, together with their color changes, is found in the appendix.

In spite of other works on the subject, "INDICATORS" is so complete, so up-to-date, so understandable, that it is bound to be very greatly in demand.

MALCOLM M. HARING

Research in Progress at the University of Minnesota, July, 1924–July, 1925. Compiled by CLARENCE M. JACKSON, M.S., M.D., Ll.D.

University of Minnesota, Minneapolis, 1926. vi + 306 pp. 23 × 15.25 cm. Paper cover. $1.25.

A more detailed account of the research in progress at the University of Minnesota than it is possible to include in the annual presidential report. The bulletin consists of abstracts containing a brief indication of the purpose of each study, the methods and materials used, and the results so far as available. The data, although mainly the results of graduate work, are grouped under the corresponding undergraduate colleges. In some cases, notably among the studies of the Mayo Foundation, abstracts are not furnished and merely titles are given.

O. R.

Super-Amplification Makes Atoms Audible by Radio. Amplifying minute electric currents 700,000,000,000 times by the use of radio vacuum tubes to make the sound of a single atom of radium audible to broadcast listeners over an area of several thousand square miles was the feat recently accomplished at the University of Kansas, in conjunction with its radio station KFKU.

The experiment was conducted by Dr. H. P. Cady, head of the chemistry department, and made use of an old-fashioned static electric machine of two revolving glass plates; a Leyden jar such as was used in the time of Benjamin Franklin, and an ultra-modern three-stage radio amplifier. Suspended within the Leyden jar was a brass cylinder about two centimeters in diameter and rising from the bottom of the jar like a lightning rod was a wire tipped with a fine needle from a talking machine. The needle was connected with the negative pole of the jar and the brass cylinder with the positive. When the jar was charged by operation of the static machine, it began to discharge until the resistance of the air between the needle point and the cylinder stopped the flow with a difference in potential of about 4000 volts.

When any radio-active substance, such as polonium, the material of a gas mantle, or a clock with luminous dial, was brought within range of the machine, some of the alpha particles from the radium got into the charged field between the point and the cylinder and ionized the air. These ions of air, by collision, multiplied the electrical force of the single alpha particle from 10,000,000 to 100,000,000 times, and this was again multiplied 70,000 times by the radio amplifier.—*Science Service*

Partnerships of Germs May Cause Disease. A theory that may have an exceedingly important bearing on the cause of many obscure diseases has been advanced by Dr. Aldo Castellani, internationally known authority on tropical disease.

There is a condition among microörganisms known as symbiosis, which in spite of its formidable sound simply means a close association of two or more organisms in a kind of alliance like matrimony, with many of its benefits but none of its drawbacks. Dr. Castellani believes that this state of symbiosis may be responsible for many symptoms and even the cause of some diseases not yet fully understood. "It seems certain," he says in a report to the American Medical Association, "that there are diseases caused by a true symbiosis or association of two organisms neither of which alone is capable of producing the malady."

He cites, as an example, common itch, the eruptions of which are not due to the mite which causes it by burrowing under the skin but to a pus-forming coccus that finds the skin irritated by the mite a particularly fertile field in which to increase and multiply. A similar condition maintains in the tropical malady, yaws, where the eruptions are likewise caused by an associated coccus and not the specific causative agent. Certain symptoms in severe cases of typhoid fever have been demonstrated, according to Dr. Castellani, to occur only in the presence of both the typhoid germ and another bacterium. Neither germ will produce the reaction alone, he says.—*Science Service*

KEEP POSTED

There is no greater satisfaction than the consciousness that one is fully informed about recent progress in chemical research and production. Also it is gratifying to know that professors and teachers in other universities and schools are carrying out tests similar to those which you had often thought of but through pressure of work could not find time to conduct. To know what progress is taking place in industry and in instruction is real joy and inspiration.

Each month, in addition to the articles and editorials dealing with the new things in chemistry, as applied to industry or instruction, there are listed in the advertising pages of the JOURNAL OF CHEMICAL EDUCATION, many new and important items. Some of these are new books, new apparatus, new sources of chemical supplies, new chemicals, etc. It pays to read the advertising pages of the JOURNAL OF CHEMICAL EDUCATION.

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Next month, many of our readers will be mighty glad to see the pay check again. What a feeling of joy it is to get one's hands upon it after a long vacation.

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No progressive educator can afford to be without this monthly "income." It stimulates his teaching. His pupils like to read it. Its illustrations are very helpful. Its editorials are pertinent. In many universities large numbers of students—yes, freshmen, are subscribing so that they may know in general what is happening in the chemical world.

Let us tell our friends about this second income